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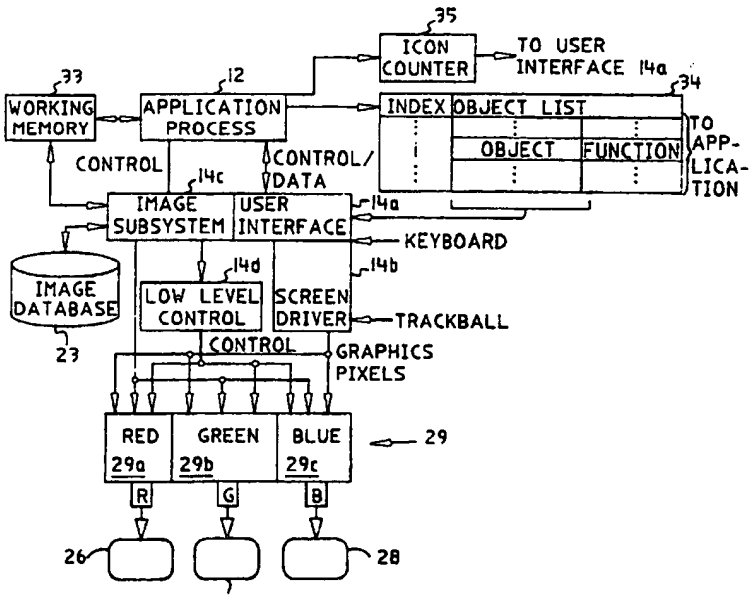
(54) Title: AN AUTOMATED SYSTEM AND A METHOD FOR ORGANIZING, PRESENTING, AND MANIPULATING MEDICAL IMAGES

(57) Abstract

An automated system for organizing, presenting, and manipulating medical images includes a database in which the medical images are structured into groups, each group including one or more image series, each image series including an ordered sequence of images which illustrate incrementally registered aspects of an anatomical target. Image series are presented in their sequential order either in a monitor presentation format which displays each sequence in its entirety in a single monitor display container or which presents two or more image series, image-by-image, in adjacent presentation areas of a series display container. The system includes a plurality of monitors in which all monitors, save one, produce display containers for image series presentation. One monitor is reserved for displaying a working palette to which images of the image series displayed on the other monitors may be moved. The system activates a monitor in a plurality of monitors in response to movement of a cursor between monitors. An active monitor is indicated by presentation of a control panel. The system also provides heads-up presentation of control panel icons at a cursor location outside of the control panel by sequentially changing the shape of the cursor to the icon shapes for user selection.



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DESCRIPTION

AN AUTOMATED SYSTEM AND A METHOD FOR ORGANIZING, PRESENTING, AND MANIPULATING MEDICAL IMAGES

TECHNICAL FIELD

The invention relates to the organization, presentation, and manipulation of images. More particularly, the invention provides efficient, user-friendly means and procedures for presenting images of anatomical structure and the like for examination.

BACKGROUND ART

The invention is also concerned with the activation of a display container for medical images in a context of a plurality of display containers, and with the presentation of icons without distracting the attention of a user from medical images which are being examined.

Magnetic resonance imaging (MRI) is an important, non-invasive imaging modality that is widely used by radiologists to examine internal anatomy to aid in the analysis of trauma and the diagnosis of disease. An MRI study provides a multi-planar representation of an anatomical target in the form of one or more image series. The images of a series may be parallel planar "slices" of the anatomical target which are incrementally registered along an imaging axis. Another imaging technology may produce image sequences which include non-parallel views that are incrementally registered about an axis of rotation or over a non-planar surface.

MRI technology is well understood. See, for example, MRI OF THE KNEE by Jerrol H. Mink, et al, Raven Press Ltd. (New York, NY 1987) and the work by F.W. Wehrli, et al, entitled PARAMETERS DETERMINING THE

OCCURRENCE OF NMR IMAGES published by the General Electric Company, Medical Systems Operations, in 1983.

In the prior art, the transparencies produced by an MRI system would be manually mounted in their series sequence on long light boxes where they would be read and annotated by radiologists. Following examination, the images would be physically stored in a patient's medical history folder. Recently, automated systems for archiving, retrieving, and presenting MRI images have been developed. In these systems, the images are conventionally converted to multi-bit, pixelated data representations which are formatted, stored, and retrieved using file management techniques. However, most conventional file management techniques are adapted for storage, retrieval, and presentation of documents, rather than images. Of course, these systems give even less consideration to the specialized requirements for storage and presentation of images showing internal anatomy.

Even the addition of a directly-manipulated user interface in conventional image storage and presentation systems does little to adapt these systems to the special needs of radiologists who must consider and manipulate many images in particular ways for special purposes. Furthermore, each radiologist has a highly personal mode of examination. For example, one radiologist may wish to examine a first sequence of transparencies in its entirety and then a second, related sequence before trying to correlate between individual images of the sequences. Another radiologist may wish to examine sequences in parallel by simultaneously considering images taken of the same anatomical plane under different conditions of exposure. Even currently-available database systems which have been adapted for storage and presentation of radiological images have not automated the presentation modalities of image series. Instead, a radiologist must provide for the individual retrieval and presentation of each and every stored image. In these systems, the images are individually identified and processed for storage and presentation without correlation to other images in their respective sequences.

Furthermore, the existing systems do not provide for concurrent presentation of related image series.

Moreover, the currently available automated image storage systems are awkward and difficult to use, providing little in the way of means for direct manipulation of image presentation formats and images which are displayed for analysis.

SUMMARY OF THE INVENTION

Therefore, it is a primary objective of this invention to provide an automated system for storage, retrieval, and presentation of medical images which is especially adapted for the presentation of medical image sequences and which affords the user with a flexible and responsive set of functions that permit direct manipulation of the modes of image presentation and of the presented images themselves.

The invention is embodied in a computer display system which presents images of anatomical structure and the like for examination. The system includes the following combination:

a first display container including a first preselected number of substantially rectangular presentation areas in a substantially rectangular array;

a second display container including a second preselected number of substantially rectangular presentation areas in a substantially rectangular array;

an image database including a plurality of images of anatomical structure, the images being separated into image groups in which:

each image group is indexed by a unique group identification; and

each image group is partitioned into one or more ordered image series, each ordered image series including a succession of

images which illustrate incrementally registered aspects of an anatomical target, each image series being ordered by assignment to each image in the image series of a position in a respective monotonically changing sequence;

a mechanism connected to the image database and to the first and second display container and responsive to a group identification for displaying at least two image series of an image group indexed by the patient identification, wherein:

each image series is displayed in the order of its respective sequence in a respective display container such that each presentation area of the respective display container includes no more than one image; or,

all of the image series are displayed in one display container and each image series is displayed one image at a time in the order of its respective sequence in a respective presentation area of the display container.

For direct manipulation of an interactive computer system with an output means for presenting visual displays wherein a user is presented with a visual display that includes a control display container (control panel), the invention further includes the following combination:

a first bounded display area presented by the output means, the first display area including:

a control panel; and

a plurality of icons displayed in the control panel;

a second bounded display area presented separately from the first display area by the output means;

a cursor mechanism connected to the output means for displaying and moving a cursor in a display area; and

a functional mechanism coupled to the first and second display areas and the to the cursor mechanism for presenting the control panel in the second display area in response to movement of the cursor from the first to the second display area.

Also, in an interactive computer system with an output means for presenting visual displays wherein a user is presented with a display that includes a directly-manipulated display container for presenting program output, the invention is embodied in a combination, in which:

a cursor mechanism is connected to the output means for displaying and moving a cursor;

a control display area is provided in the display in which a plurality of icons are displayed in a predetermined order;

a pointing mechanism is provided, with connection to the cursor mechanism, for positioning the cursor and selecting icons in response to direct manual manipulation by a user; and

an icon rotation mechanism is provided, with connection to the pointing mechanism and to the cursor mechanism, which responds to a position of the cursor inside the display container by changing the shape of the cursor at the position to the shape of an icon of the plurality of icons and by changing the shape of the cursor to the shapes of the other icons in the plurality of icons, such that the shape of the cursor is changed one shape at a time and in the predetermined order, in response to direct manual manipulation of the pointing mechanism.

BRIEF DESCRIPTION OF DRAWING

The invention, and its achievement of the above-stated objective, will be understood when the following detailed description is read in connection with the below-described drawings, in which:

Figure 1 is a block diagram illustrating basic components of an automated system for storing, retrieving, and displaying medical images;

Figure 2 is a block diagram illustrating in greater detail certain components of the system of Figure 1;

Figure 3 is an illustration of a display container output on a monitor of the system of Figure 1 for a presentation of medical images according to one mode of the invention;

Figure 4 is an illustration showing a display container for presentation of medical images according to a second mode of the invention;

Figure 5 is an illustration showing a working palette display container presented on a monitor of the system of Figure 1;

Figure 6 illustrates the organization of a medical image database according to the invention;

Figure 7 is a flow diagram illustrating how the database of Figure 6 is accessed;

Figure 8 is a flow diagram illustrating how the system of Figures 1 and 2 presents images according to the first mode of the invention;

Figure 9 is a block diagram illustrating presentation of images according to the first mode of the invention;

Figure 10 is a flow diagram illustrating how the system of Figures 1 and 2 presents images according to the second mode of the invention;

Figure 11 is a block diagram illustrating presentation of images in a database of Figure 6 according to the second mode of the invention;

Figure 12 is a flow diagram illustrating a procedure for indicating an active monitor according to the invention;

Figure 13 is a flow diagram illustrating a procedure for rotating image manipulation icons according to the invention;

Figures 14a through 14d are illustrations of display containers showing icon rotation according to the procedure of Figure 13;

Figure 15 is a flow diagram illustrating annotation rotation according to the invention;

Figure 16 is an illustration showing a display container with annotation rotation according to the procedure of Figure 15.

DISCLOSURE OF INVENTION

The invention is intended to operate in connection with an image database which stores medical images for retrieval and presentation. Although the following description assumes that the images are data representations of pixelated images conventionally produced from the output of medical imaging technology such as MRI, X-ray, and CAT, this is not intended to limit such images to such sources. The inventors contemplate that the means and processes presented in this description would apply as well to a database of synthetically-created medical images.

In the preferred embodiment and best mode of this invention, the medical images are, in fact, those produced from an MRI apparatus. As is known, such an apparatus produces series, or sequences of images, which represent successively deeper planar slices of an anatomical target. In the examples given below, the anatomical target is the head of a human patient and it is assumed that three distinct series of images have been taken of the target. Two of these series are termed "axial". The images of an axial series represent parallel, planar images of cross-sectional anatomy taken along an imaginary vertical axis of the head. Each axial series is generated to emphasize particular anatomical features by varying parametric values of the MRI process. In this regard, see Chapter 1 of the Mink et al reference. The two axial series described in this embodiment are the well-known axial T1 and axial T2 sequences. The third series is a sagittal sequence in

which the images are anatomical cross-sections lying in planes parallel to the median plane of the head.

It is assumed, without further explanation, that axial and sagittal images obtained from an MRI apparatus will have been digitized and rendered into conventional scanned, pixelated data representations that can be processed by the computer system illustrated in Figure 1. In Figure 1, the system includes a DOS-based personal computer or work station 10 which has the capability to concurrently execute an application process 12 and a plurality of interface processes 14. The application process which, preferably, is written in the well-known C language, embodies processes and functions of the invention as described later in further detail. The interface processes 14 include commercially available programs as well as processes which can be constructed by the reasonably skilled computer programmer with the following description in hand. The interface processes 14 are connected to standard I/O devices such as a conventional trackball mechanism 16, a conventional QWERTY keyboard 22, and output devices 23 such as a full grey scale printer, a facsimile machine, and a modem (none of which is illustrated). The trackball mechanism 16 is a conventional picking device that includes a left button 18, a right button 19, and a rotation ball 20. The trackball mechanism 16 provides a user with the means for directly manipulating the position and functions of a cursor. The keyboard 22 is manually operated to input alphanumeric characters. The output devices 23 operate conventionally to provide tangible, visual results produced by the invention as described in further detail below. An image database 24 includes one or more conventional on-line storage devices for storage of medical image data representations which have been generated as described above. Therefore, the image database 24 includes not only the storage hardware, but also the stored images and all necessary indices. An output device 25 in the form of a multi-screen apparatus provides the means by which the images stored in the image database 24 are arranged and presented to a practitioner for examination, manipulation, and disposition. In the preferred

embodiment, the device includes three separate output monitors 26, 27, and 28 which are connected by a coupling mechanism 29 to the interface processes 14 for control by the application process 12.

Figure 2 shows certain architectural aspects of the best mode for practicing the invention in a system such as that illustrated in Figure 1. In Figure 2, the interface processes 14 include a conventional directly-manipulated user interface 14a which is directly connected to a screen driver 14b. The screen driver 14b is connected to the trackball mechanism 16 and the keyboard 22, passing inputs from these devices by conventional means directly to the user interface 14a. The screen driver 14b also operates in conjunction with the user interface 14a to provide the pixel information necessary to draw and manipulate graphics on the monitors 26, 27, and 28.

The graphics include a cursor, display containers which give a visible structure for image presentation, and a control panel in which icons and function buttons are displayed. It is assumed that the user interface includes the ability not only to generate a cursor, but also to move the cursor among the monitors in response to trackball motion. It is further presumed that the user interface includes the ability to highlight icons and control buttons which have been "pointed to" by the cursor and "clicked" by a trackball mechanism button. The interface processes 14 further include an image subsystem 14c and a low level video controller 14d. The image subsystem 14c accesses the image database 23 for retrieval of stored images. Image selection is made by the application process 12 and indicated by control signals coupled to the image subsystem 14c. In response to control signals which designate images to be retrieved, the image subsystem 14c obtains the data representations of the specified images and enters them into a high-capacity working memory 33 as directed by the application process 12. The application process 12 further specifies how and which images in the working memory 33 are to be output on the monitors 26, 27, and 28. Thus, the pixel information representing database images flows from the working memory 33, through the

image subsystem 14c to the monitors 26, 27, and 28. Control over the display apparatus 25 is provided by the coupling mechanism 29 in the form of a video card which has separately accessed and separately controlled memories for Red, Green, and Blue pixels. These memories are indicated by reference numerals 29a, 29b, and 29c, respectively. The memories of the video card are controlled by a low-level video controller 14d, which receives control signals from the image subsystem 14c. The image subsystem 14c generates control input for the low-level controller 14d in response to control signals generated by the application process 12. In the architecture illustrated in Figure 2, each of the memories 29a, 29b, and 29c is connected by a respective gun of a tri-color output to a particular video monitor. In particular, the Red memory 29a is connected by way of a Red (R) video output connector to the monitor 26, the Green memory 29b by a Green (G) video output connector to the monitor 27, and the Blue memory 29c by a Blue (B) video output connector to the monitor 28. The monitors 26, 27, and 28 are operated in the monochromatic mode and the memories 29a, 29b, and 29c are operated effectively as frame buffers for the monitors to which they are connected. This architecture merely reflects the design choices of the inventors in implementing the invention, and is not intended to limit the use of equivalent architectures. For example, instead of separate video monitors 26, 27, and 28, a designer might select an architecture which provides separate display containers (windows) on a single, large video monitor so that each window operates as a separate, independently-controlled monitor.

The application program 12 employs object-oriented programming techniques to provide programming controls and cues to the user interface 14a and the imaging subsystem 14c. Controls and cues are in an object list 34 which is initiated and updated as needed by the application process 12. The object list has a conventional structure in that it includes a plurality of objects, each of which represents some feature or attribute of a display which is presented on one of the monitors 26, 27, or 28. Objects in the object list 34 are conventionally indexed.

Each object includes one or more application process functions and any data necessary to establish machine state when the object is encountered or otherwise identified during system operation.

The application process 12 maintains and increments an icon index 35 whose output is provided to the user interface 14a for accessing the object list 34 in a procedure described later in greater detail.

IMAGE PRESENTATION

The invention is practiced on a system architecture corresponding to that illustrated and discussed above. The invention is concerned with the presentation of one or more medical image series for consideration, analysis, and disposal by a user such as a radiologist. The invention includes at least two modes for presenting medical image series. The first mode is illustrated in Figure 3.

Figure 3 illustrates what is termed the "monitor" mode of image presentation. Figure 3 illustrates a rectangular display container which is produced on one or more monitors for presentation of image series. The series shown in Figure 3 is an axial T2 series including 18 images. The display container is subdivided into a rectangular array of 20 presentation areas. In the monitor mode of image presentation, an image series is shown in a single display container in its sequence order such that each presentation area of the display container includes one image of the sequence. Only one image series at a time is shown in any display container. Separate series are shown in separate display containers. The axial T2 sequence illustrated in Figure 3 is ordered by assignment to each image in the series of a monotonically increasing number. The number assigned to an image represents the image's position in the sequence of which it is a member. In Figure 3, therefore, the image in the upper left-hand presentation area is the first image of the axial T2 sequence, with the next image in the sequence being assigned the number 2 and being displayed in the next presentation area of the

display container to the right of the presentation area where image number 1 is shown.

In the monitor mode of the presentation, a display container such as that illustrated in Figure 3 is output on all but one of the monitors or monitor equivalents supported by the system. Thus, in Figures 1 and 2, a display container such as shown in Figure 3 would be presented on, for example, monitors 26 and 27, with monitor 28 being reserved for presentation of a work product palette as described below. This permits more than one image series to be presented, with each image series being presented in its sequence order in a presentation area of a respective display container on a particular monitor. Since co-relative series such as axial T1 and axial T2 typically consist of an identical number of images taken at identical planes, identical side-by-side presentations of axial T1 and T2 series on adjacent monitors in the manner illustrated in Figure 3 contributes significantly to a radiologist's ability to differentially analyze the images.

Figure 4 illustrates a second presentation mode of the invention which is termed the "series" mode. In the series mode, a display container comprising a rectangular array of rectangular presentation areas is displayed on one or more monitors. For example, the display container in Figure 4 includes four substantially rectangular presentation areas numbered 1, 2, 3, and 4 in the drawing. In the invention, each presentation area of a series mode display container is employed to display an image series, one image at a time, in the order of its respective sequence. In this regard, consider presentation area 2 in which an axial T2 series is illustrated. Assume that the axial T2 series is identical to that illustrated in Figure 3. Thus, the images of the axial T2 series would be shown in presentation area 2 beginning with image 1 and continuing sequentially until image 18 is shown. Assume next that a co-relative axial T1 series comprising 18 images is presented in presentation area 1 in the display container of Figure 4. An important feature of the invention termed "coupling" is employed to synchronize the presentation of the axial T1 and T2 series so that whenever an image of one

series is changed to the next image in the series, the other series is changed identically to display the image of the other series occupying the same sequence position. Thus, if presentation area 1 in the display container of Figure 4 displays image 1 of the axial T1 series and then riffles through the images of the series, the display in presentation area 2 would identically riffle through the images of the axial T2 series, beginning with image 1. The invention contemplates that the coupling feature of the series mode of presentation will synchronize image presentation only between co-relative image series. Thus, for example, an axial T1 series would be coupled for a presentation with an axial T2 series, but not with a sagittal T1 series such as that shown in presentation area 4 of the display container in Figure 4.

The series mode of presentation is practiced by presenting the display container of Figure 4 on all available monitors or monitor equivalents except one, which is also reserved for the working palette display container.

Refer now to Figure 5 for an illustration of the working palette display container. This display container is presented on one monitor of a multi-monitor system, such as monitor 28 in Figures 1 and 2. The working palette display container has a substantially rectangular aspect and is subdivided into a rectangular array of individual presentation areas. The working palette is provided to receive individual images which are picked and copied from presentation areas in monitor mode or series mode display containers. The working palette allows a radiologist to assemble the images which are deemed to be the most important in illustrating trauma or disease for provision to a referring physician. For example, the axial image displayed in presentation area 3 of the working palette display container may have been copied there from presentation area 12 in the monitor mode display container of Figure 3.

Figure 6 illustrates the structure of the image database which enables the efficient storage and retrieval of image series. When an MRI apparatus is used to generate images, examination protocols normally provide for identification of the

patient, and set out the number and types of sequences which are to be taken and the anatomical target of interest. From this information, a unique composite patient identifier (ROOTNAME) is algorithmically derived. A patient, thus, has a unique ROOTNAME for each MRI examination. A patient identification, the corresponding ROOTNAME, and an identification of a referring physician are entered for each patient examination into a database file 50 entitled "PATIENT.dB". For any patient identification entered in the file 50, its corresponding ROOTNAME points to an examination file such as the file 53, which is entitled "ROOTNAME.PAT". Each examination file 53 identifies an image group including one or more image series obtained during an examination. Each image series in an image group is indexed to a set of sequentially named or numbered files in which the images of the series are contained. For example, in the ROOTNAME.PAT file 53 illustrated in Figure 6, the image group includes axial T1, axial T2, and sagittal T1 series. The axial T1 series consists of n consecutively-numbered files, each containing a respective image of the series such that the sequence position of the named file corresponds to the sequence position of the image it contains. The image files are named ROOTNAME.XXX. Thus, image 1 in the axial T1 series has a file name ROOTNAME.1, the second image in this series is in a file named ROOTNAME.2, and so on. Similarly, the n images of the axial T2 series are stored in files consecutively numbered as ROOTNAME.m through ROOTNAME.(m+n). When a patient is identified to the application process 12, the application process determines a ROOTNAME value for that patient, obtains a ROOTNAME.PAT file, and commands the image subsystem to extract the image series contained in the ROOTNAME file sequence defined by the ROOTNAME.PAT file and place them in linked list form in the working memory 33. The application process 12 then presents the image series to a radiologist and provides the radiologist's work product assembled in a working palette, to the referring physician.

The file-naming rule for image series is important to the invention because it preserves the unique identity, and the order, of each image series. For any given ROOTNAME, an image series can be identified by reference to the ROOTNAME file 53 and manipulated, as a unit and independently of any other image series, by the system of Figures 1 and 2. This provides a very significant advantage over the existing systems which treat each image as an independent unit, unconnected with any other image in its sequence or with any other image in any other series or group.

As Figure 6 illustrates, the PATIENT.dB file includes a REFERRING PHYSICIAN column containing values which index to entries in a REF.DOCS file 52. The REF.DOCS file 52 lists referring physicians. Each referring physician entry includes a set of functions specified by the identified referring physician which are to be executed when a radiologist indicates that examination of an image group is completed by pressing a DONE button, which is explained later in more detail. A RADSTAFF.dB file 63 includes at least seven columns. In the first column (RAD NAME) are listed the names of radiologists having access to the system. The second through sixth columns comprise a format specification for the monitors in which the image series are to be displayed. The seventh column includes a working palette specification. The format specification, columns two through six of the Table 63, include a MODE column, identifying the monitor or series mode of presentation, a MATRIX column setting forth the number of rows and columns in the display containers, and a COUPLE column specifying whether the coupling function is invoked for synchronization of two or more image series in a series mode of presentation. The format specification further includes SHRINK and EXPAND columns which specify whether the rows and columns of the matrix are to be adapted to predefined dimensional parameters for display containers. The seventh column specifies the matrix size of the working palette. The application process also has access to a set of annotation lists 60 and to the

set of image functions that are linked to objects which are in or which may be added to, the object list 34 of Figure 2.

Figure 7 illustrates the procedure executed by the application process 12 to initialize the system of Figures 1 and 2 for presentation of images. The procedure starts at step 70 by receipt of an indication that the PATIENT.dB file is to be read. In step 71, a list illustrating the PATIENT.dB file is constructed and presented on one of the monitors. It is assumed that the user can select the name of a patient simply by moving a cursor to the patient's name in the displayed list and clicking on the name by depressing and releasing a trackball button. The decision 73 awaits selection of a patient. In decision 73, the negative exit can be manually selected. If the negative exit is taken from decision 73, the procedure is exited. If a patient is selected, the positive exit is taken from decision 73 and a search is conducted of the database for a ROOTNAME.PAT file for this patient in step 74. If the file does not exist, a warning message to the operator is displayed on the monitor in step 75. Otherwise, the ROOTNAME.PAT file is provided to the application process which extracts the image group organization from the file in step 77, and passes the appropriate control signals to the imaging system in step 78 to enable the imaging subsystem to copy the images named in the ROOTNAME.PAT file from the image database to the main memory. In step 79, a list illustrating the RADSTAFF.dB file is presented in a manner permitting a radiologist to log on by pointing to and clicking his name in the list. When the radiologist's name is identified in this manner, the format specification and working palette matrix size in the same RADSTAFF.dB row are provided to the application process 12 which enables it to initialize control blocks for each monitor, as well as the object list, in step 80. The object list includes a full specification of the graphics objects required in the first monitor for the mode and the matrix size, and palette size specified in the RADSTAFF.dB entry selected by the user. The first monitor is then initialized with graphics and images in steps 81 and 82. Once the first monitor has been initialized, the object list is updated for

specifying the graphics of the second monitor, and then is updated once again to specify the working palette graphics for the third monitor. The third monitor is initialized with graphics in step 83. The application process then executes the appropriate presentation mode procedure. In the preferred embodiment, the monitors 26 and 27 in Figures 1 and 2 are formatted with display containers of the specified mode and matrix size and populated with images and then the monitor 28 is formatted with the specified working palette.

Referring once again to Figures 1 and 2, when the object list 34 is initialized or updated, the application process provides a "SELECT MONITOR" control signal to the image subsystem 14c. This signal is appropriately conditioned to indicate the monitor to which control is to be transferred. In response, the image subsystem configures the low level controller 14d to enable the appropriate one of the memories 29a, 29b, or 29c. For example, when the object list is initialized, the SELECT MONITOR control signal forces the low level controller 14d to enable the Red memory 29a to receive the appropriate display container graphics established in the object list 34. The user interface 14a inspects the object list 34 to determine the graphics objects for which graphics pixels must be generated and provided by the screen driver 14b. The screen driver 14b outputs the specified graphics pixels in parallel to all of the memories 29a, 29b, and 29c. The pixels, however, are read into only the currently-enabled memory.

Once the series of an image group have been entered in sequence order into the working memory 33 and the display containers have been initialized, the application process produces the appropriate image system control signals to present an initial image display in the specified presentation mode. If, for example, the monitor mode has been specified, graphics pixels for presenting a display container such as that illustrated in Figure 3 in the specified matrix size are entered into the Red memory 29a of the video card together with image pixels for the first series of the image group. When the memory 29a is appropriated loaded

with graphics and image pixels, the application process issues a SELECT MONITOR control signal to the low level controller 14d through the image subsystem 14c, which disables data entry to the Red and Blue memories 29a and 29c and enables data entry into the Green memory 29b. Graphics pixels and image pixels for the second series of the image group are entered into the memory 29b and the SELECT MONITOR signal is once again issued so that graphics pixels for the working palette can be entered into the Blue memory 29c. Next, the object list is updated to describe the Red memory 29a, the Red memory 29a is enabled, and the cursor is generated. The cursor pixels are fed to the enabled memory and updated therein when the cursor is moved.

At this point, display containers with images would be presented on the monitor 26 and on the monitor 27, while an empty working palette would be displayed on the monitor 28.

Returning to Figure 3, assume that the monitor display container and image series in this figure are displayed on monitor 26 as shown in the figure. Thus, the presented display includes a rectangular area adjacent the right edge of the display container. This area is referred to as the "control panel" and contains a plurality of function buttons (DONE, CHANGE SERIES, and PRINT), a set of image manipulation icons immediately below the function buttons, and a set of annotation icons below the image manipulation icons. Any of the function buttons and any of the image manipulation or annotation icons can be activated by "point and click" using the trackball to point with the cursor, and the left cursor button to click on a button or icon.

The function buttons represent application process functions that can be activated by pointing and clicking. The DONE button, when activated, invokes the "DONE" functions of the referring physician. The CHANGE SERIES button, when activated, deletes the series presently displayed in the display container and enters the images of the next series listed in the ROOTNAME.PAT file. The PRINT button invokes an application process function which prints a copy of the

screen. As also illustrated in dashed outline in Figure 3, another button may be presented in a control panel between the DONE and CHANGE SERIES buttons. The button may be a NEXT or a PREVIOUS button. When the image series includes more images than there are presentation areas in the display container, the NEXT button replaces the currently-displayed subset of consecutively numbered images of the series with the following subset. So long there are images remaining to be presented, the NEXT button will be presented. When the last subset of the image series is displayed in the display container, the PREVIOUS button is displayed. When activated, the PREVIOUS button returns the previous subset of series images in the display container. It should be evident that the NEXT and PREVIOUS buttons are displayed only in monitor mode control panels.

The set of image manipulation function icons is positioned immediately beneath the PRINT button. These icons control various image manipulation functions. The upper left-most icon is a magnifying glass and controls a conventional zoom function which magnifies or minifies an image in response to trackball motion. Immediately beneath the zoom icon is a riffle icon in the form of a spaced set of pages. In response to trackball motion, the riffle function shuffles through an image series in forward or reverse sequence. Beneath the riffle icon is an icon representing illumination which adjusts the contrast or brightness of an image in response to trackball motion. Immediately to the right of the zoom icon is a roam icon consisting of four outwardly-directed arrows. The roam function is used in conjunction with the zoom function and moves a magnified image under a viewing aperture in response to trackball motion. The icon in the shape of a movie camera immediately beneath the roam icon denotes the cine function, which is an automated riffle that, once selected, automatically steps through an image series in sequence order. The speed of the cine function is controlled by the trackball.

A set of annotation icons consisting of four arrows and A and X and a rectangular box is presented immediately beneath the image manipulation icons. These icons are discussed later in more detail.

As Figures 3 and 4 illustrate, the cursor has a default shape in the form of a hollow arrow.

Refer now to Figures 3, 8, and 9 for an understanding of a monitor presentation format procedure according to the invention. Once the displays in the monitors 26, 27, and 28 have been initialized for monitor presentation as described above, the monitor format procedure begins. This procedure executes in response to cursor location and trackball button activation. Thus, in step 90, beginning with monitor 26, for example, and using the cursor location and sensing button activation, the procedure determines whether one of the image manipulation icons has been selected in decision 91. If so, the image function is performed at the cursor location. Otherwise, the negative exit is taken from decision 91 and the status of the CHANGE SERIES button is inspected in decision 92. If the button function has been activated, the next series listed in the ROOTNAME.PAT file is moved into the display container grid of the monitor where the cursor is located when the left button of the trackball mechanism is clicked. Now, a series counter (not shown) for the monitor is updated to identify the series currently displayed on the monitor. If the function has not been activated, the negative exit is taken from decision 92. In decision 93, the application process determines whether a working palette grid location has been selected for placement of an image. In this regard, the application process maintains a working palette grid pointer which is updated to the next working palette grid location when an image is moved to the current one. The grid pointer can also be forced to a grid location by moving the cursor from the monitor where it is currently located to the monitor where the working palette is displayed and pointing and clicking a grid location in the working palette display container. Preferably, a working palette grid location is selected by clicking the left button of the trackball mechanism. (Once an image

has been moved to a preselected working palette grid location, the grid pointer is reset to indicate the next empty grid location which was available before user selection.) The cursor is then returned to a monitor which shows an image series. Decision 94 assumes that the cursor is in a presentation area of the monitor mode display container. If the right button of the trackball mechanism is clicked, the application process infers that the user wants the image in the presentation area moved to the working palette grid location indicated by the palette grid pointer. In this case, the image at the cursor location and any annotation graphics which it contains are copied into the working palette grid at the location indicated by the working palette grid pointer. Refer to Figure 9 for an understanding of how the application process accomplishes this step.

In Figure 9, three monitor control blocks 100, 102, and 103 are illustrated. The application process maintains the control blocks, each of which completely describes in object form the current display on a particular monitor. For example, the monitor control block 100 lists the identification and location of each graphical object displayed on the monitor 26. This would include a complete object description of a monitor mode display container, a control panel, if a monitor is active, and the images of the series presented in the display container. For example, consider the first image of an axial T1 series which is listed in grid location 1, corresponding to the upper left-hand presentation area in the display container of Figure 3. The monitor control block 100 also lists the graphics displayed at the grid location. When an image is to be moved to the working palette it is copied from the object indexed by the current cursor location in the control block of the monitor where the cursor is located to the palette monitor control block at the grid location indicated by the working palette grid pointer 104. In order to effect the update on the working palette display container presented on the palette monitor 28, the application process, using the palette monitor control block, updates the object list to describe the updated working palette display container and issues a SELECT MONITOR control signal. In response to the

SELECT MONITOR control signal, the image subsystem accesses the working memory to obtain the pixels for the image to be moved and enters them into the Blue memory 29c which has been enabled by the SELECT MONITOR signal. At the same time, the screen driver 14b provides any annotation pixels for the image which may be described in the object list. This causes the selected image and accompanying graphics to be added to the working palette presented on the monitor 28. When entry of the image and graphics pixels in the Blue memory 29c is complete, the application process updates the object list to describe the display presented in the monitor where the cursor is located and issues a SELECT MONITOR signal to enable the corresponding color memory.

In decision 95, the application process inspects the cursor location to determine whether the cursor has been moved to another monitor. If so, the object list is updated to the configuration of the monitor where the cursor is located and the SELECT MONITOR control signal is conditioned to enable the corresponding color memory for the new monitor.

In decision 96, if a DONE button is selected, the application program executes the DONE functions for the referring physician. These may include, for example, simply printing out a hard copy of the working palette display container and entering the printout into the patient's file, faxing a data or an image copy of the working palette display container to a predetermined location, or transmitting a data representation of the working palette monitor through a modem to a predetermined location.

Refer now to Figures 4, 10, and 11 for an understanding of a series presentation format procedure according to the invention. Once the displays in the monitors 26, 27, and 28 have been initialized for series presentation as described above, the format procedure begins. This procedure executes in response to cursor location and trackball activation. Thus, in step 110, beginning with monitor 26, for example, using cursor location and sensing button activation, the procedure determines whether one of the image manipulation icons has been selected in

decision 111. If so, the image manipulation function is filtered at decision 112 to determine whether the riffling function has been invoked with the coupling feature selected. If not, the negative exit is taken from decision 112 and the image manipulation function is performed in the presentation area where the cursor is located. On the other hand, if the riffling function has been invoked with coupling activated, the positive exit is taken from decision 112. Here, the images of the series being output through the presentation are where the cursor is located are riffled (in response to trackball motion) in the presentation area where the cursor is located. In addition, the images of any coupled series are riffled at the presentation area where the coupled series is displayed. The riffling is in synchronism with riffling the series at the cursor location. Decision 113 tests the CHANGE SERIES button of the control panel. If the button has been activated, the procedure waits until the cursor is moved to a display container presentation area and the left button is clicked. Then, the series is changed to the next ROOTNAME.PAT file image series. When the series is changed, the first image of the next series is displayed at the presentation area where the cursor is located. Step 116 moves images to the working palette display container in the manner described above for the monitor presentation format. Next, monitor processing and DONE button processing are performed in decisions 117 and 118 as discussed above in connection with Figure 8.

Figures 4 and 11 illustrate how the working palette is populated with images during the series presentation mode. In the series presentation mode, the application process maintains a monitor control block for each of the monitors 26, 27, and 28. The monitor control blocks are, respectively, 120, 121, and 122. Assume that the series presentation display containers such as the display container illustrated in Figure 4 are presented on the monitors 26 and 27. For each monitor, the control block must list the principal objects which, for the display container of Figure 4, are the four presentation areas of the control panel and the icon control panel. The control block links a respective series with each of the presentation

areas in the IMAGES column of the block. In the COUPLING column, a related image series is listed if the coupling function has been invoked. The GRAPHICS column lists the graphics for, and in, each presentation area. The monitor control block 121 fully describes the display container and control panel displayed on the monitor 27, while the control block 122 fully describes the working palette presented on the monitor 28. A grid pointer 122a is used to denote the current working palette grid location in the manner described above in connection with Figure 9.

ACTIVE MONITOR INDICATION

The invention also includes the ability to indicate, by the control panel, which monitor is currently active. In this regard, the "active" monitor is most likely the one wherein the cursor is currently located. The configuration of the active monitor is fully described in the object list; user inputs are received through it; and application response is provided through it. Manifestly, it would be inefficient and distracting to the user to have to remember which monitor is active by devoting full attention to the cursor's location. Positioning the cursor in a particular monitor might, in some instances, not indicate the active monitor. In addition, as described later, the shape of the cursor may change, causing the user to lose track of it and the active monitor.

In the invention, the active monitor is indicated by the presence of a control panel. Preferably, when a user moves a cursor to a monitor boundary which is shared with another monitor, the cursor is moved from the one monitor (which is called the "last" monitor) to the monitor which is adjacent the boundary of the last monitor (which is called the "next" monitor). The last monitor is then deactivated and the next monitor is activated. In response to movement of the cursor from the last monitor to the next, the control panel in the last monitor is turned off and the control panel is presented in the next monitor.

The procedure for performing the active monitor indication function is illustrated in the flow diagram of Figure 12. Initially, the cursor position is read in step 123. When the cursor location is the same as the location of a boundary object defined in the object list of the current monitor, the application process prepares to deactivate the present monitor. In this regard, the positive exit is taken from the decision 124 and the application process issues control signals which turn off the control panel of the last monitor in step 125, reconfigures the object list to define all of the objects, including the boundaries, in the next monitor in step 126, and then executes a series of next monitor routines in step 127. One next monitor routine is conditioning of the SWITCH MONITOR signal to enable the color memory for the next monitor. Additional next monitor routines are shown in step 128. In step 128, cursor graphics pixels are configured to place the cursor adjacent the boundary in the next monitor which is closest to the last monitor. Next, the control panel is turned on in the next monitor and the procedure returns to step 123.

The control panel deactivation/activation sequence to indicate monitor activation is not necessarily limited to turning off the control panel in the last monitor and turning on the control panel in the next monitor. Other visual cues may be used. For example, the control panel colors may be inverted or changed in intensity.

ICON ROTATION

The invention also provides a "heads up" feature which permits a user to select an image manipulation icon without shifting attention from a presentation area to the control panel. This is accomplished by moving the cursor one time to an image manipulation icon in the control panel, changing the shape of the cursor to that icon, moving the cursor back to a presentation area, and rotating the shape of the cursor at that location through the succession of image manipulation icon

shapes in response to motion of the trackball, and selecting an icon function at the location where the cursor shape has been changed.

Refer to Figures 13 and 14a-14d for an understanding of the icon rotation function of the invention. Initially, in decision 131, the cursor position read at step 130 is evaluated to determine whether it is over one of the image manipulation icons in the control panel. Positioning the cursor over one of these icons and clicking the left button causes the cursor to change its shape from a default shape (preferably, a hollow arrow) to the shape of the selected icon and results in illumination of the icon at the control panel as provided in step 133. The result of performing step 133 is illustrated in Figure 14a where the shape of the cursor has been changed to the riffle icon shape comprising a set of pages. Selection of the icon at its control panel location will not immediately invoke the corresponding function because the image manipulation functions are intended to execute with respect to a selected image. Thus, to invoke the selected function, the cursor, now in the shape of the selected icon, must be moved to one of the presentation areas. Therefore, in step 134, the position of the cursor (now in the shape of an icon) is read and when decision 135 determines that the cursor is in an image display container, the positive exit is taken and decision 136 checks the status of the left button on the trackball mechanism. If the left button is not down, the procedure loops through 134, 135, and 136 until it detects depression of the left button. When the left button is held down and the trackball is moved, the shape of the cursor is successively changed to the shapes of the image manipulation icons in their order of presentation in the control panel. This is illustrated in Figure 14b where the cursor, in the shape of the riffle icon, is moved to the lower left corner of the top right presentation area of the illustrated series display container. Assuming that the user continues to hold the left button down while moving the trackball (136, 137, 138), the icon counter (indicated by reference numeral 35 in Figure 2) is incremented or decremented in response to the trackball motion. The threshold check in step 139 indicates when the trackball

has moved far enough to increment to the next value of the icon counter. The icon counter indexes to the portion of the object list which contains the image manipulation icons. These objects are numbered consecutively in the object list so that, by constraining the icon counter to cycle through a count sequence which corresponds to the index numbers of the icon objects, the user interface and video driver are enabled to correspondingly cycle through the icon shapes at the cursor location. In step 140, the shape of the cursor is changed at its location to the next image manipulation icon shape in sequence.

For example, consider Figures 14b-14d where the cursor initially has the shape of the riffle icon. Assume that the trackball is moved in a certain direction, resulting in change of the icon counter to a value which corresponds to the magnifying glass icon shape. The result is illustrated in Figure 14c, where the cursor shape is changed to the magnifying glass. Further movement of the trackball in the same direction results in change at the icon counter to a value corresponding to the image motion icon consisting of four outwardly directed arrows shown in Figure 14d. As illustrated in step 140, and in Figures 14b-14d, each time the cursor shape is changed to that of the next icon in the icon rotation procedure, the corresponding icon is illuminated on the control panel at the cursor location. The decision in step 141 continues the icon rotation loop until the left button is released. In this regard, for so long as the left button is held down and the negative exit is taken from decision 141, the decision at 142 either loops back to the decision 141 if there is no trackball motion or back up to step 138 if there is further trackball motion. If, after icon rotation, the left button is released, the positive exit is taken from decision 141 and a click of the left button is searched for by entering decision 136 through C.

The sequence 136, 137, 145 signifies a left button click to select an icon function, with the function being performed in step 146. This sequence can be entered by selecting an icon shape at the control panel, moving the cursor in the form of the shape to a display container, and then clicking the left button, as at

136, 137, 145. Alternatively, the clicking sequence is detected out of the positive exit from decision 141 after icon rotation when the left button is released. Note that the clicking sequence is exited if trackball motion is detected in step 137 following depression of the left button in step 136 before the left button is released (step 145). Any appropriate reset sequence will restore the cursor to its default shape.

IMAGE ANNOTATION

Image annotation is provided by the set of annotation icons which is beneath the image manipulation icon set in the control panel. Arrows may be dragged from this icon set and selectively dropped on images by moving the cursor to the arrow, clicking the left button to change the shape of the cursor to the arrow, and moving the cursor in the arrow shape to the desired location. At the desired location, clicking the left button will "drop" the arrow at the location. Any appropriate RESET routine will return the cursor to its default shape.

An image can be annotated by selecting the A icon in the control panel, dragging the icon to a location where annotation is desired, clicking the left button of the trackball mechanism and then using the keyboard to annotate the image at the cursor location.

Figures 15 and 16 illustrate a procedure executed by the application process for automatically annotating a figure using the annotation lists indicated by reference numeral 60 in Figure 6. Initially, it is asserted that the application process includes logic capable of selecting an annotation list which is appropriate to the anatomical target. Thus, for example, a sagittal image sequence of a portion of the spine would identify an annotation list which included shorthand annotations commonly employed to identify individual vertebra. The procedure of Figure 15 provides for the rotation of an annotation list through the annotation box which is illuminated in the annotation icon group in Figure 16. When this icon is selected, the cursor assumes its shape and is moved in response to the trackball to the

desired location. At the desired location, the left button of the trackball is depressed in order to couple the annotation list to the box at the cursor location and in the control panel. For so long as the left button is depressed, motion of the trackball will rotate the listed annotations through the annotation box outlined in the image and in the control panel. When the appropriate annotation is rotated into the box, the left button is released. When the left button is clicked again, the annotation will be dropped in the shape of the annotation box at the cursor location and the cursor's shape will be changed back to the default shape with the tip of the cursor pointing to the lower left-hand corner of the annotation box in the image. This is illustrated in Figure 16 and the procedure laid out in Figure 15.

In Figure 15, when the cursor is clicked at the annotation box, positive exits are taken from decisions 150 and 151, the box icon is illuminated at the control panel and the cursor in the shape of the box is moved to a desired location. When the left button is depressed while the cursor is in an image display container, the positive exits are taken from decisions 152 and 153 and the annotation list is rotated through the box shape in steps 154. When the left button is released and clicked again, the annotation is dropped at the last cursor position and the cursor shape is restored.

The X icon in the annotation set (Figure 16) is used to delete annotations from an image. Initially, the X icon is clicked using the cursor. This illuminates the X icon and changes the cursor to the icon shape. The cursor is moved over the annotation to be deleted and the left trackball button is clicked. This removes the annotation from the object list and from the image, restores the cursor to its default shape, and turns off the X icon in the control panel.

Clearly, other embodiments and modifications of this invention will occur readily to those of ordinary skill in the art in view of these teachings. For example, cursor movement and clicking can be controlled from a keyboard. Furthermore, the images which are stored in the database may be actual images taken from the human patient, may be images taken from a veterinary subject, or

may be synthesized images. Therefore, this invention is to be limited only by the following claims, which include all such embodiments and modifications when viewed in conjunction with the above specification and accompanying drawings.

CLAIMS

1. A computer display system for presenting images of anatomical structure and the like for examination, including:

a first display container means for presenting a first preselected number of substantially rectangular presentation areas in a substantially rectangular array;

a second display container means for presenting a second preselected number of substantially rectangular presentation areas in a substantially rectangular array;

an image database including a plurality of images of anatomical structure, the images being separated into image groups, in which:

each image group is indexed by a unique group identification; and

each image group is partitioned into one or more ordered image series, each ordered image series including a succession of images which illustrate incrementally registered aspects of an anatomical target, each image series being ordered by assignment to each image in the image series of a position in a respective monotonically changing sequence; and

means connected to the image database and to the first and second display container means and responsive to a group identification for displaying at least two image series of an image group indexed by the patient identification;

each image series being displayed in the order of its respective sequence in a respective display container such that each presentation area of the respective display container includes no more than one image.

2. A computer display system for presenting images of anatomical structure and the like for examination, including:

at least one display container means for presenting a preselected number of substantially rectangular presentation areas in a substantially rectangular array;

an image database including a plurality of images of anatomical structure, the images being separated into image groups, in which:

each image group is indexed by a group identification; and

each image group is partitioned into one or more ordered image series, each ordered image series including a sequence of images which illustrate incrementally registered aspects of an anatomical target, each image series being ordered by assignment to each image in the image series of a position in a respective monotonically changing sequence; and

means connected to the image database and to the display container means and responsive to a group identification for displaying at least two image series of an image group indexed by the patient identification;

each image series being displayed one image at a time in the order of its respective sequence in a respective presentation area.

3. In an interactive computer system with an output means for presenting visual displays wherein a user is presented with a visual display that includes a control display container (control panel), a combination, comprising:

a first bounded display area presented by the output means, the first display area including:

a control panel; and

a plurality of icons displayed in the control panel

a second bounded display area presented separately from the first display area by the output means;

a cursor means connected to the output means for displaying and moving a cursor in a display area; and

means coupled to the first and second display areas and to the cursor means for presenting the control panel in the second display area in response to the cursor moving from the first display area to the second display area.

4. The combination of Claim 3, further including:

a first boundary in the first display area; and

a second boundary in the second display area;

wherein the means is further for moving the control panel in response to the cursor moving across the first boundary toward the second boundary.

5. The combination of Claim 4, wherein the means is further for positioning the cursor just inside the second boundary in response to the cursor moving across the first boundary toward the second boundary.

6. The combination of Claim 3, wherein the means is further for activating the control panel in the second display area and deactivating the control panel in the first display area in response to the cursor moving from the first display area to the second display area.

7. The combination of Claim 3, wherein the means is for displaying the control panel in the second display area and for turning off display of the control panel in the first display area.

8. In an interactive computer system with an output means for presenting visual displays wherein a user is presented with a display that includes a directly-manipulated display container for presenting program output, a combination, comprising:

a cursor means connected to the output means for displaying and moving a cursor;

a control panel in the display in which a plurality of icons are displayed in a predetermined order

a pointing means connected to the cursor means for positioning the cursor and selecting icons in response to direct manual manipulation by a user; and

icon rotation means connected to the pointing means and to the cursor means and responsive to a position of the cursor inside the display container for changing the shape of the cursor at the position to the shape of an icon of the plurality of icons and for changing the shape of the cursor to the shapes of other icons of the plurality of icons, such that the shape of the cursor is changed, one shape at a time in the predetermined order, in response to direct manual manipulation of the pointing means.

9. The combination of Claim 8, further including means for illuminating icons displayed in the control panel in response to changing the shape of the cursor while the cursor is within the display container, wherein the means for illuminating illuminates an icon whose shape is the shape of the cursor.

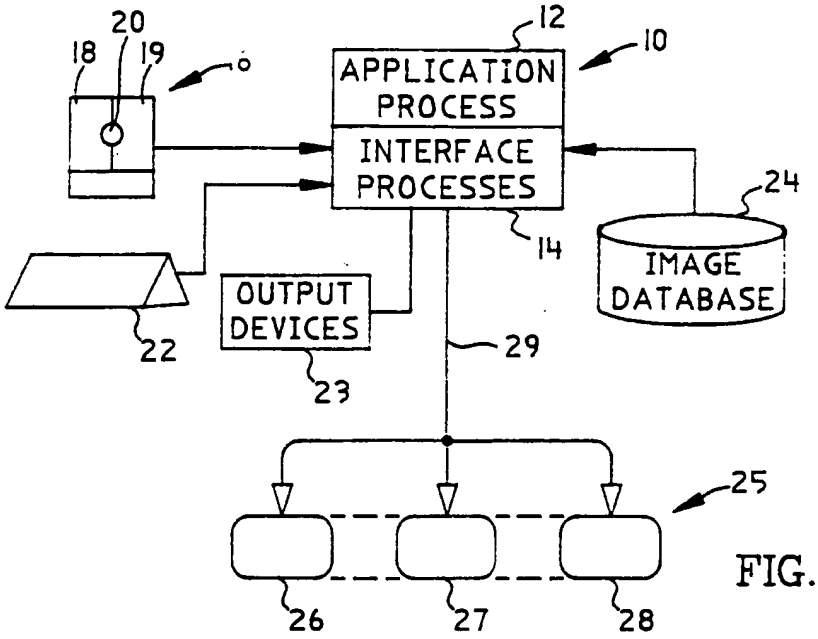

20
18
19
12
10
APPLICATION PROCESS
INTERFACE PROCESSES
14
24
IMAGE DATABASE
OUTPUT DEVICES
22
23
29
25
26
27
28

FIG. 1

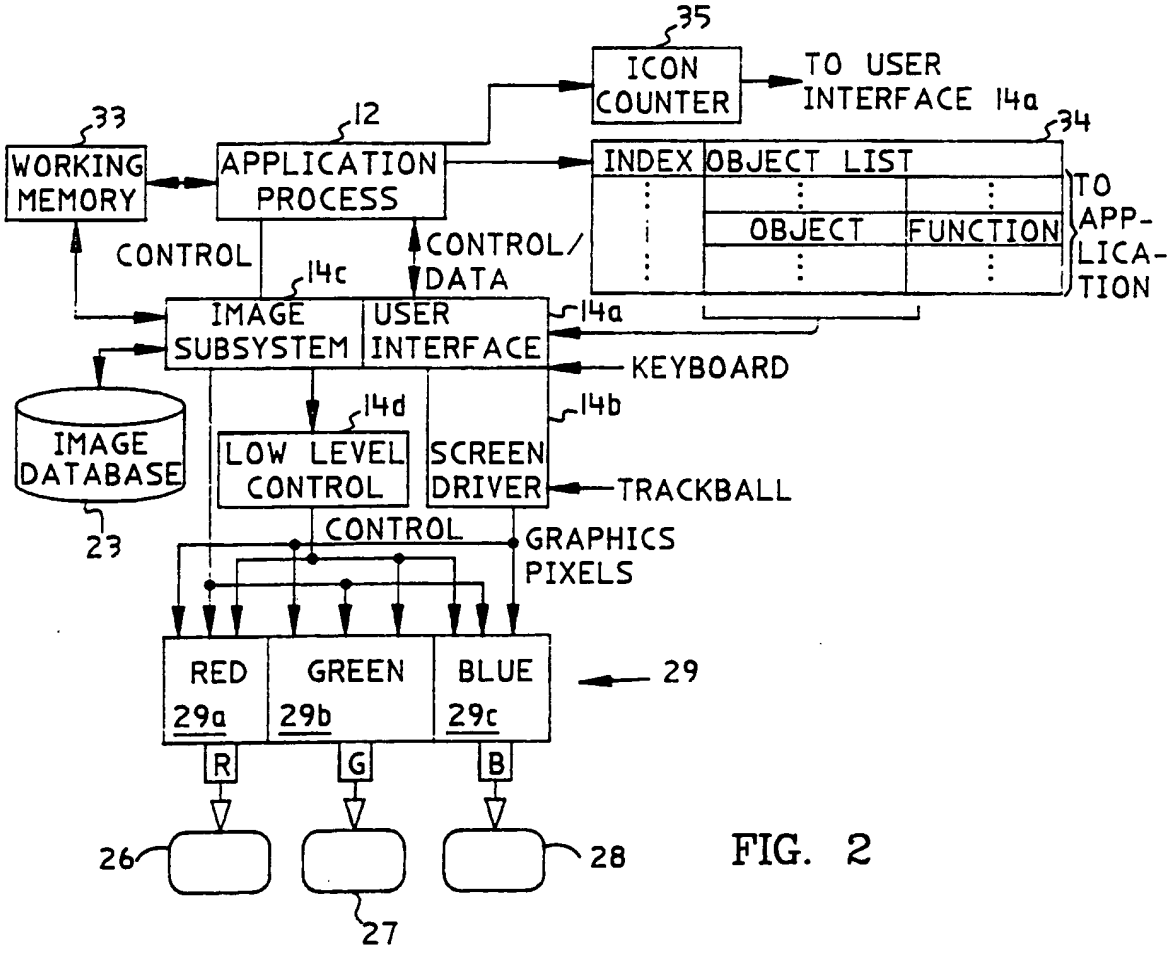

35
ICON COUNTER
TO USER INTERFACE 14a
33
12
34
WORKING MEMORY
APPLICATION PROCESS
INDEX
OBJECT LIST
OBJECT
FUNCTION
TO APP-LICA-TION
CONTROL
CONTROL/ DATA
14c
IMAGE SUBSYSTEM
USER INTERFACE
14a
KEYBOARD
14d
14b
IMAGE DATABASE
LOW LEVEL CONTROL
SCREEN DRIVER
TRACKBALL
23
CONTROL
GRAPHICS PIXELS
RED
GREEN
BLUE
29
29a
29b
29c
R
G
B
26
28
27

FIG. 2

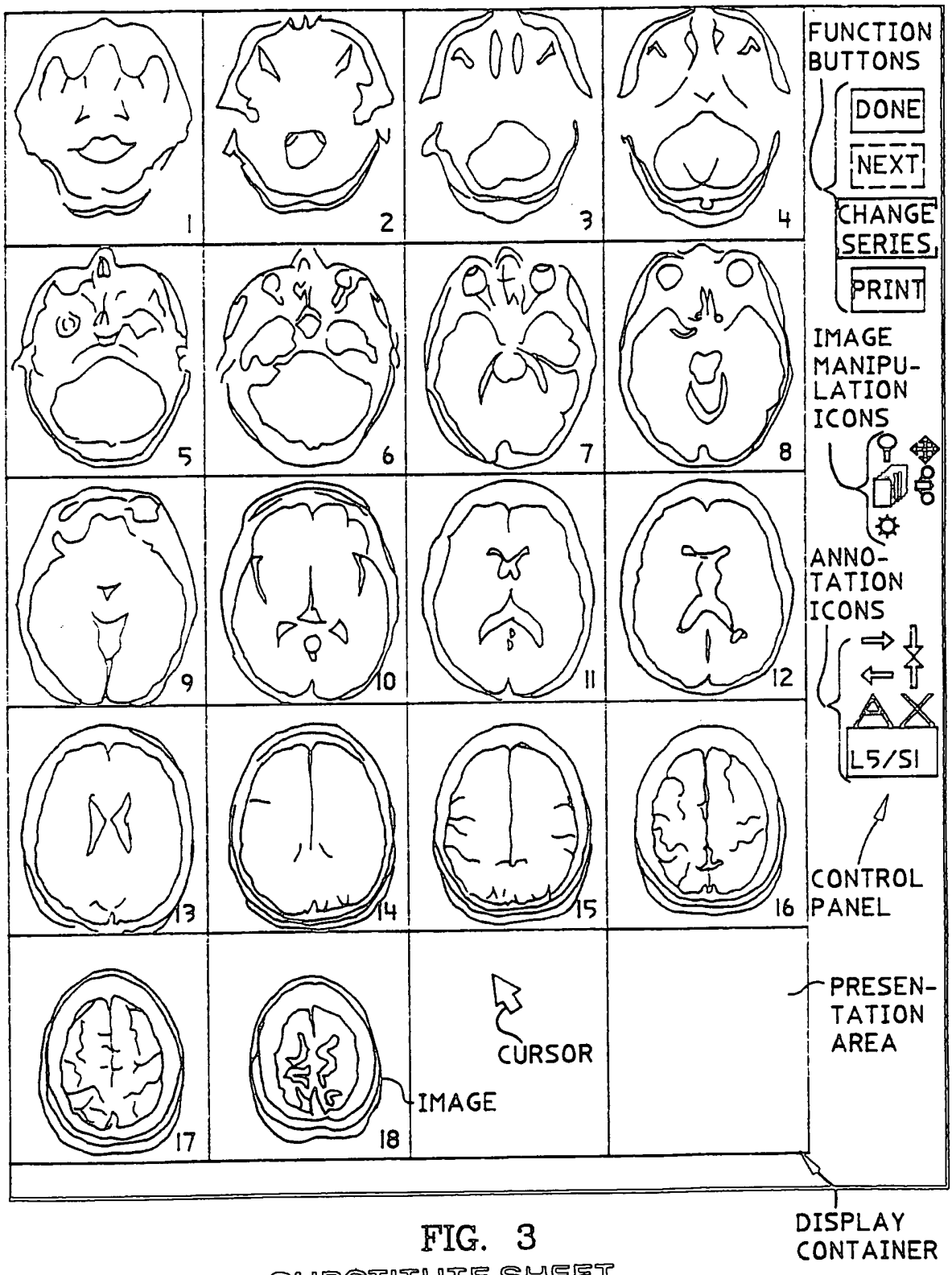

FUNCTION BUTTONS
DONE
NEXT
CHANGE SERIES
PRINT
IMAGE MANIPU-LATION ICONS
ANNO-TATION ICONS
L5/S1
CONTROL PANEL
PRESEN-TATION AREA
CURSOR
IMAGE
DISPLAY CONTAINER
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18

FIG. 3

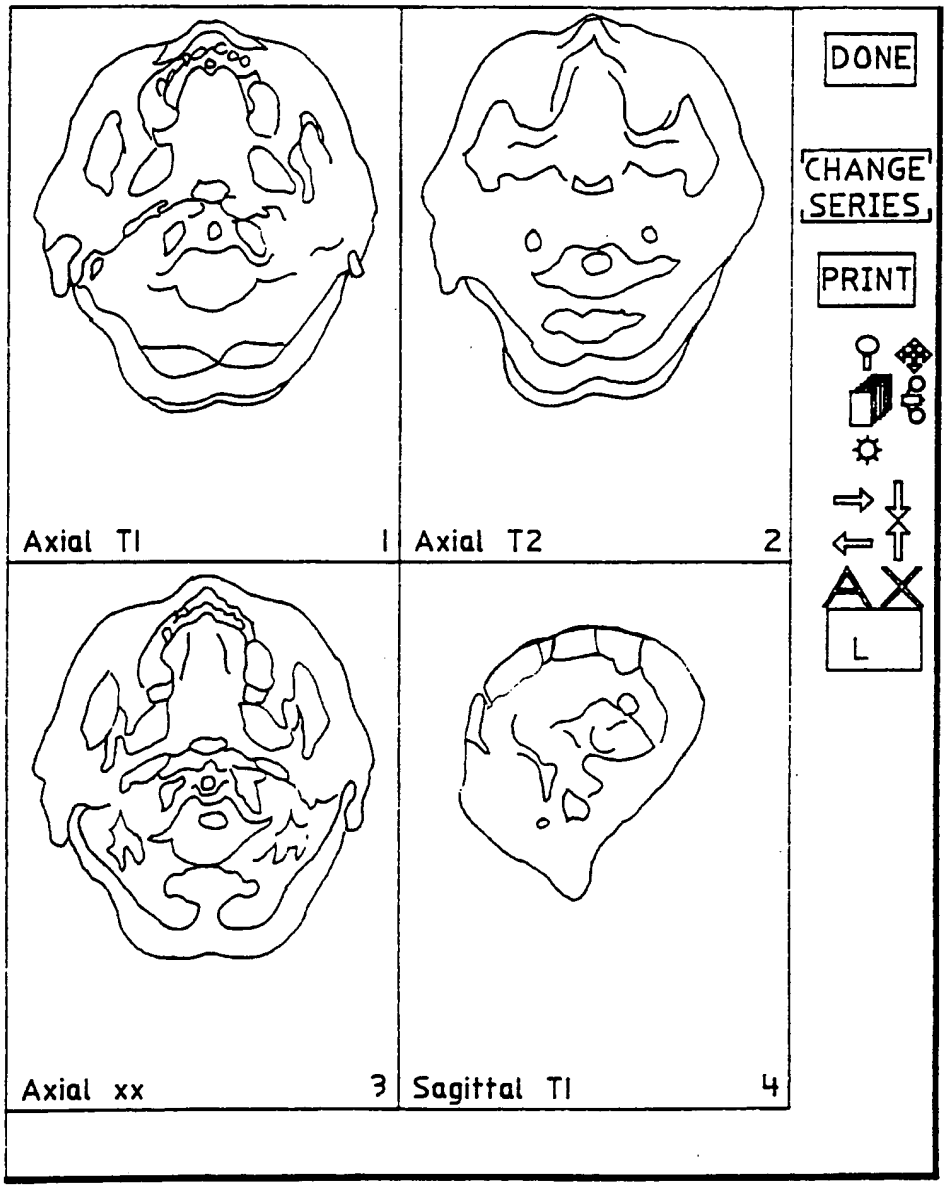
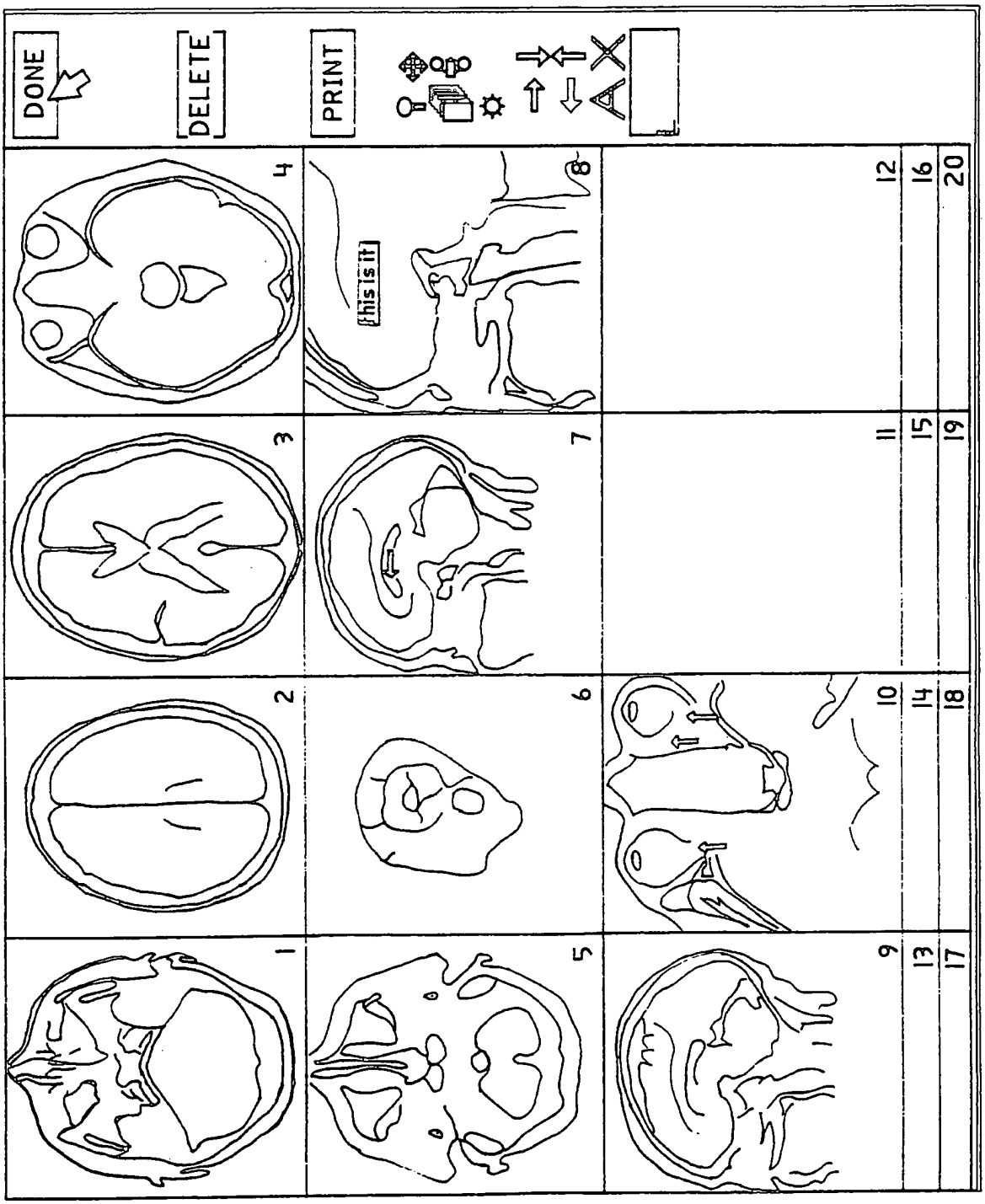


FIG. 4

FIG. 5


DONE
DELETE
PRINT
this is it
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20

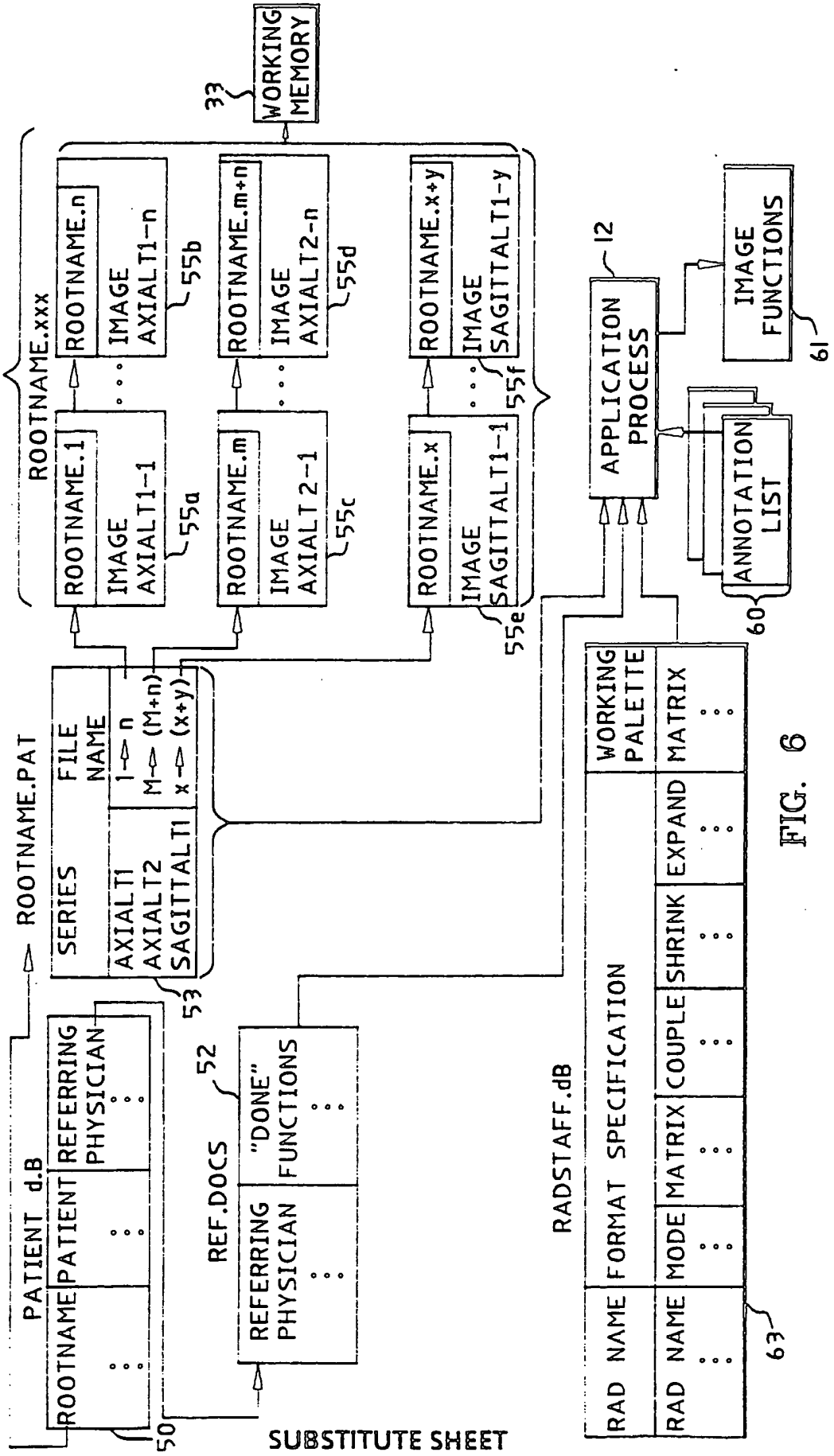

WORKING MEMORY
33
IMAGE.dB 55
ROOTNAME.xxx
ROOTNAME.1
IMAGE AXIALT1-1
55a
ROOTNAME.n
IMAGE AXIALT1-n
55b
ROOTNAME.m
IMAGE AXIALT2-1
55c
ROOTNAME.m+n
IMAGE AXIALT2-n
55d
ROOTNAME.x
IMAGE SAGITTALT1-1
ROOTNAME.x+y
IMAGE SAGITTALT1-y
55e
55f
APPLICATION PROCESS
12
IMAGE FUNCTIONS
61
ANNOTATION LIST
60
ROOTNAME.PAT
SERIES
FILE NAME
AXIALT1
AXIALT2
SAGITTALT1
1 ⇔ n
M ⇔ (M+n)
x ⇔ (x+y)
53
WORKING PALETTE
MATRIX
EXPAND
SHRINK
COUPLE
MATRIX
MODE
FORMAT SPECIFICATION
RAD NAME
RAD NAME
RADSTAFF.dB
63
PATIENT d.B
ROOTNAME
PATIENT
REFERRING PHYSICIAN
50
REF.DOCS
REFERRING PHYSICIAN
52
"DONE" FUNCTIONS

FIG. 6

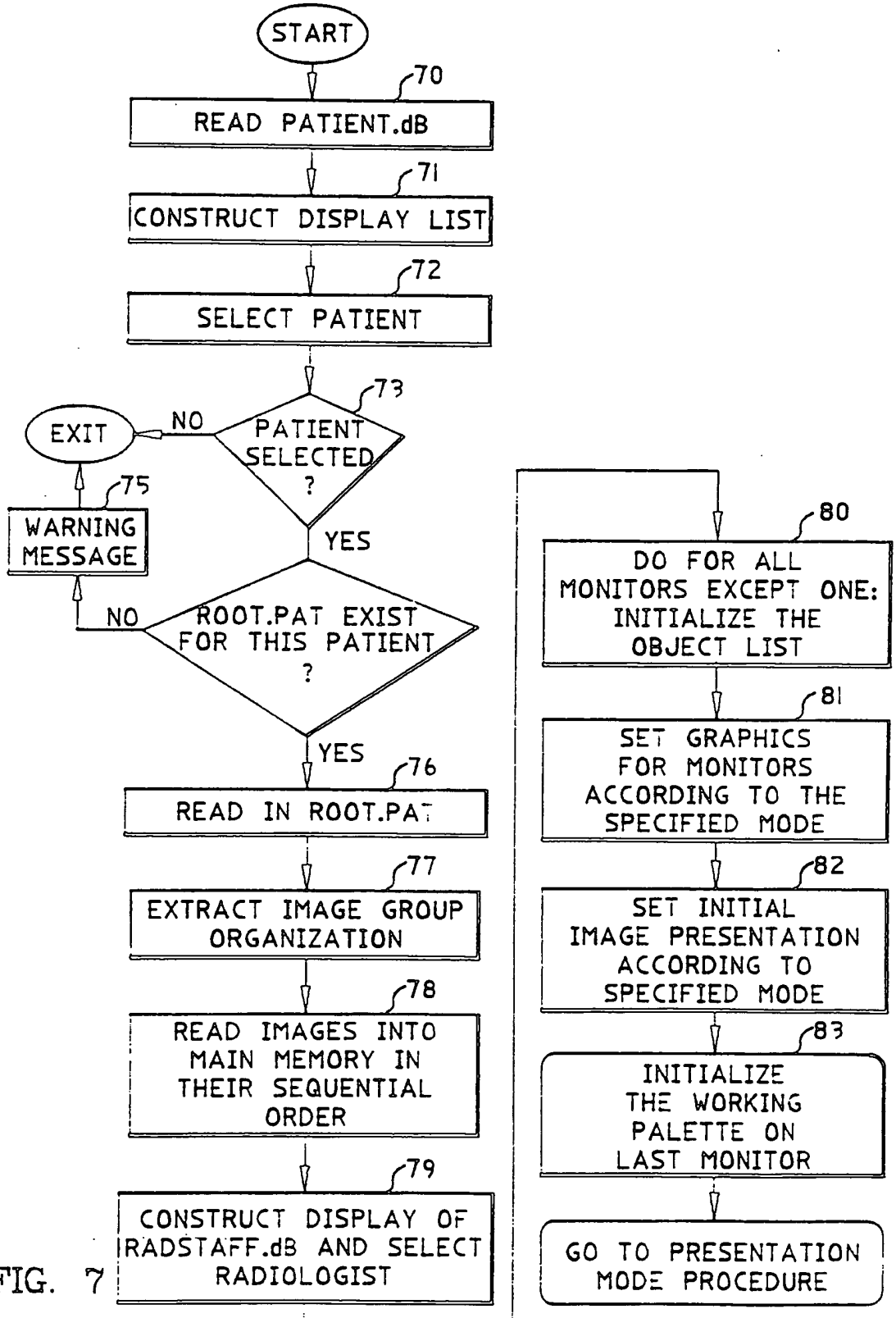
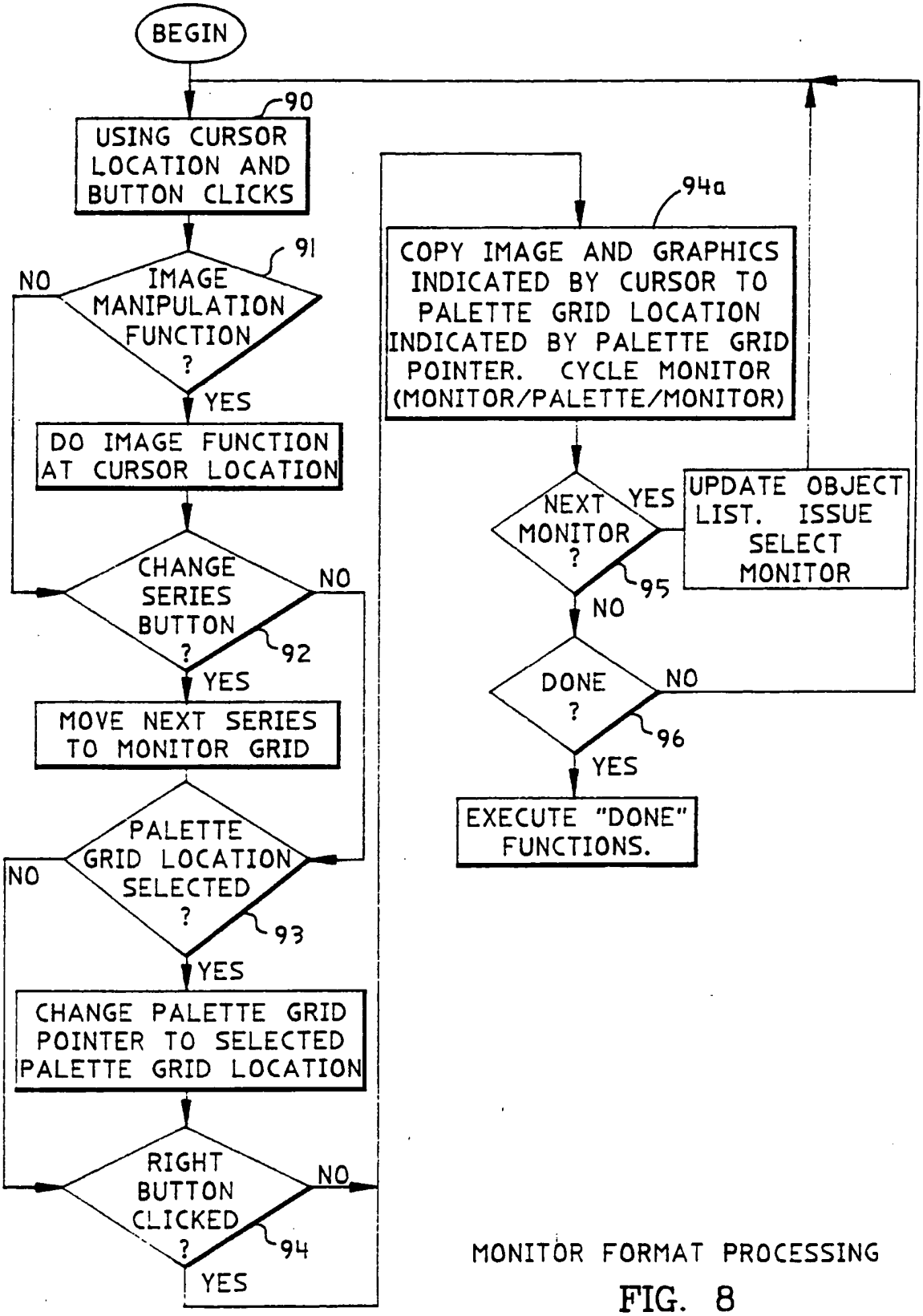

START
70
READ PATIENT.dB
71
CONSTRUCT DISPLAY LIST
72
SELECT PATIENT
73
PATIENT SELECTED ?
NO
EXIT
YES
75
WARNING MESSAGE
NO
ROOT.PAT EXIST FOR THIS PATIENT ?
YES
76
READ IN ROOT.PAT
77
EXTRACT IMAGE GROUP ORGANIZATION
78
READ IMAGES INTO MAIN MEMORY IN THEIR SEQUENTIAL ORDER
79
CONSTRUCT DISPLAY OF RADSTAFF.dB AND SELECT RADIOLOGIST
80
DO FOR ALL MONITORS EXCEPT ONE: INITIALIZE THE OBJECT LIST
81
SET GRAPHICS FOR MONITORS ACCORDING TO THE SPECIFIED MODE
82
SET INITIAL IMAGE PRESENTATION ACCORDING TO SPECIFIED MODE
83
INITIALIZE THE WORKING PALETTE ON LAST MONITOR
GO TO PRESENTATION MODE PROCEDURE

FIG. 7



MONITOR FORMAT PROCESSING

FIG. 8

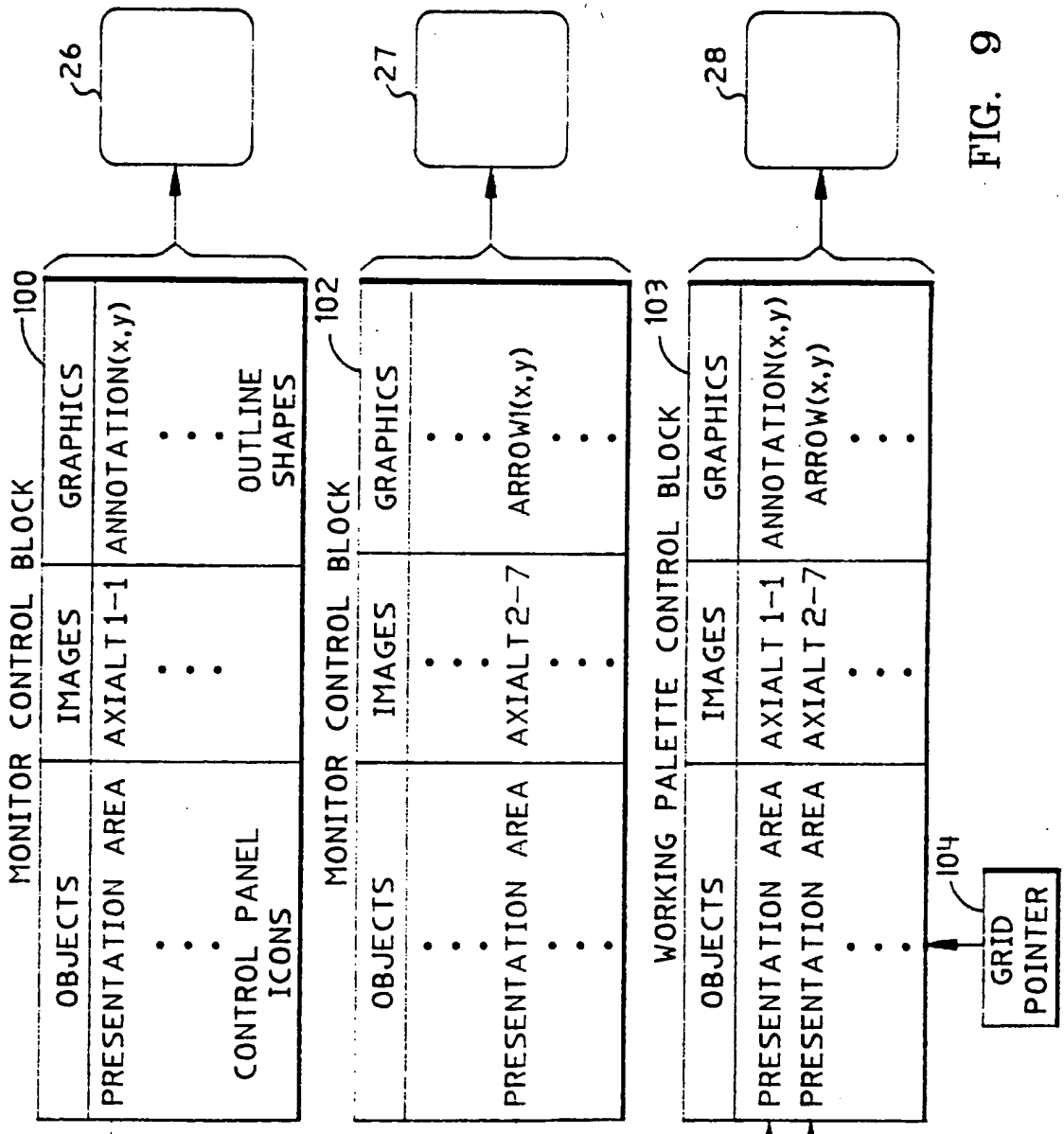


FIG. 9

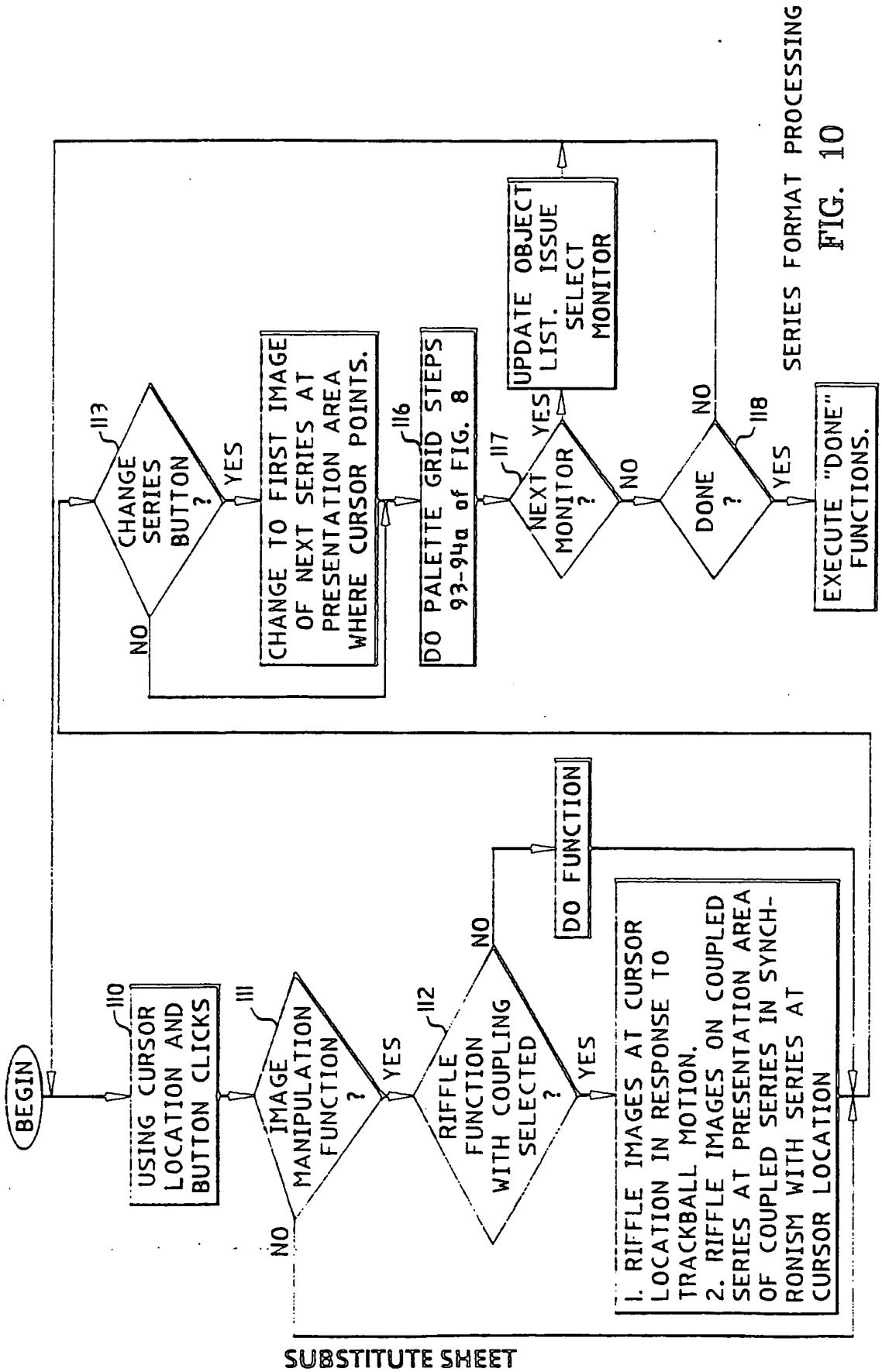

BEGIN
110
USING CURSOR LOCATION AND BUTTON CLICKS
111
IMAGE MANIPULATION FUNCTION ?
YES
NO
112
RIFFLE FUNCTION WITH COUPLING SELECTED ?
YES
NO
DO FUNCTION
1. RIFFLE IMAGES AT CURSOR LOCATION IN RESPONSE TO TRACKBALL MOTION.
2. RIFFLE IMAGES ON COUPLED SERIES AT PRESENTATION AREA OF COUPLED SERIES IN SYNCH-RONISM WITH SERIES AT CURSOR LOCATION
113
CHANGE SERIES BUTTON ?
YES
NO
CHANGE TO FIRST IMAGE OF NEXT SERIES AT PRESENTATION AREA WHERE CURSOR POINTS.
116
DO PALETTE GRID STEPS 93-94a of FIG. 8
117
NEXT MONITOR ?
YES
NO
UPDATE OBJECT LIST. ISSUE SELECT MONITOR
DONE ?
NO
YES
118
EXECUTE "DONE" FUNCTIONS.
SERIES FORMAT PROCESSING

FIG. 10

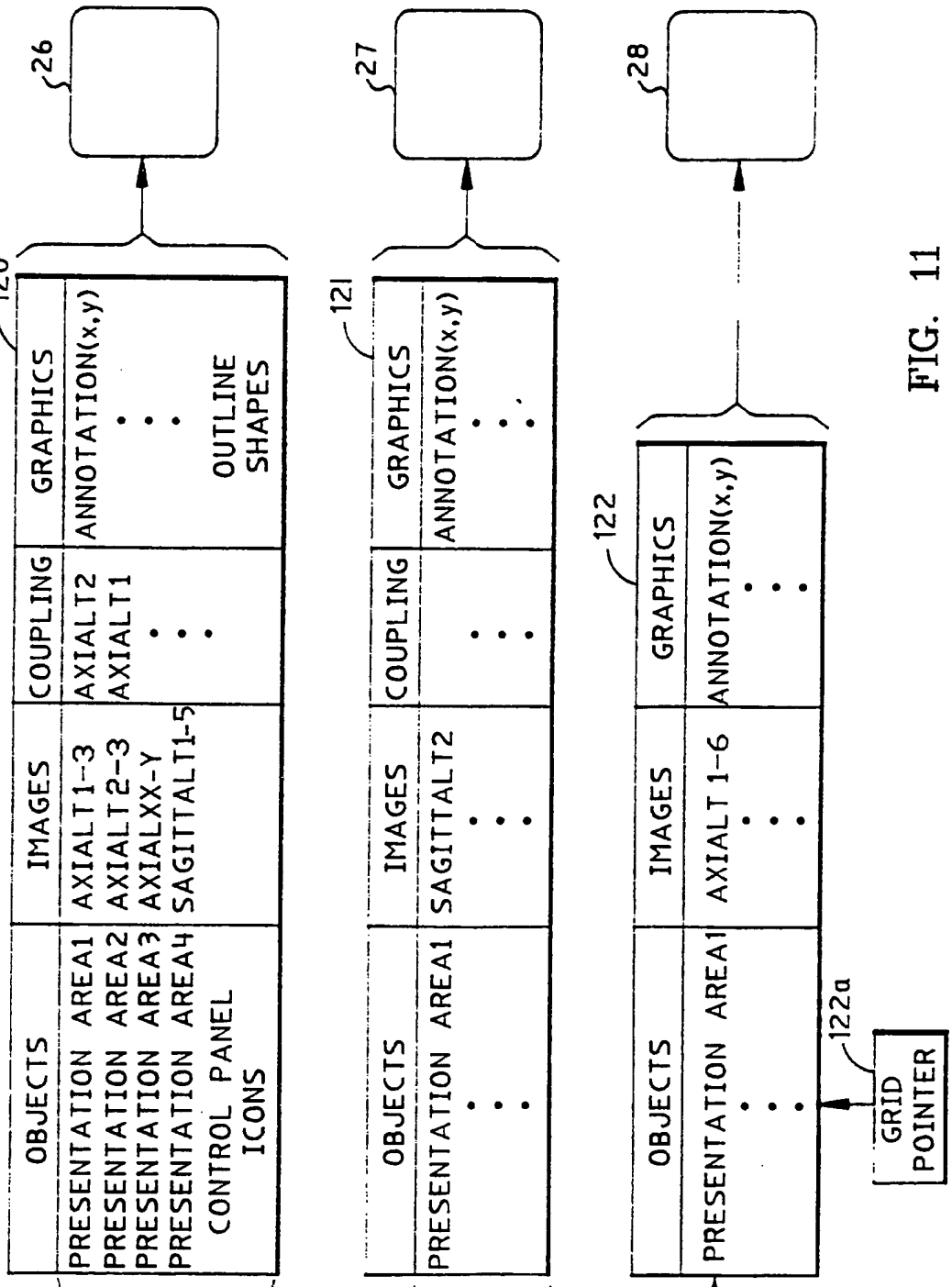

26
27
28
120
121
122
OBJECTS
IMAGES
COUPLING
GRAPHICS
PRESENTATION AREA1
PRESENTATION AREA2
PRESENTATION AREA3
PRESENTATION AREA4
CONTROL PANEL ICONS
AXIALT1-3
AXIALT2-3
AXIALXX-Y
SAGITTALT1-5
AXIALT2
AXIALT1
ANNOTATION(x,y)
OUTLINE SHAPES
SAGITTALT2
AXIALT 1-6
122a
GRID POINTER

FIG. 11

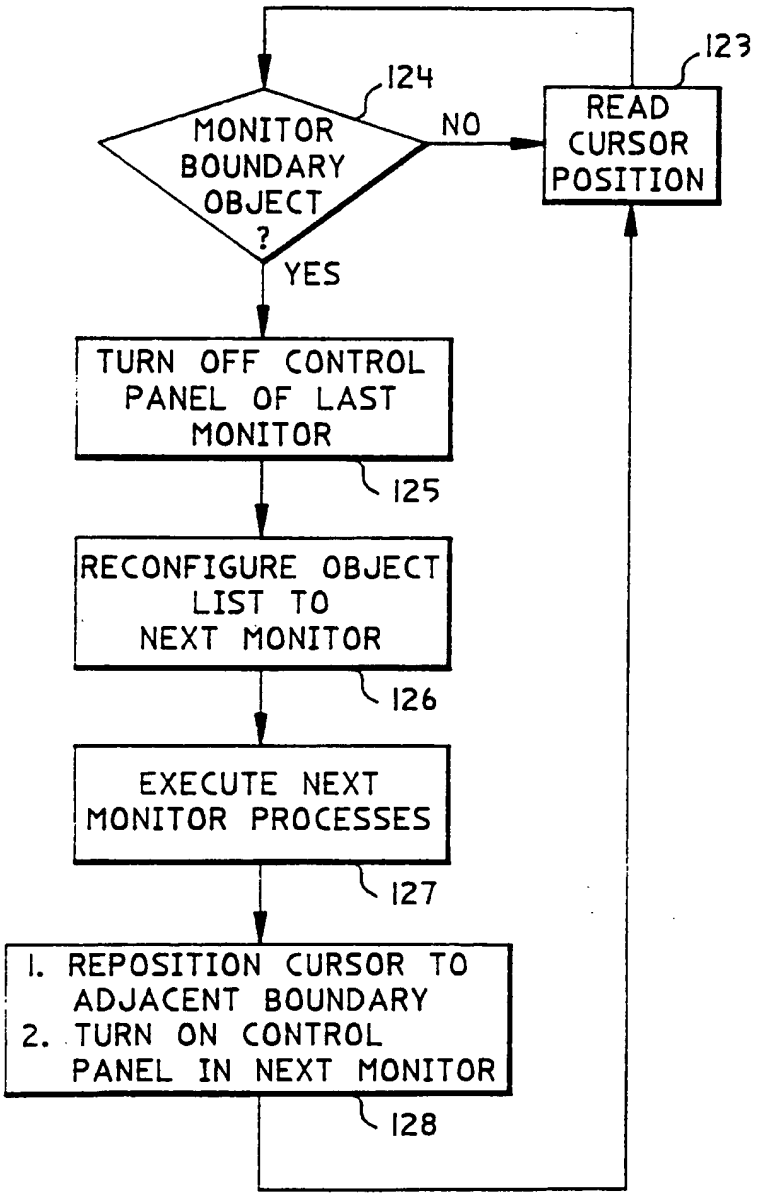

123
124
MONITOR BOUNDARY OBJECT ?
NO
READ CURSOR POSITION
YES
TURN OFF CONTROL PANEL OF LAST MONITOR
125
RECONFIGURE OBJECT LIST TO NEXT MONITOR
126
EXECUTE NEXT MONITOR PROCESSES
127
1. REPOSITION CURSOR TO ADJACENT BOUNDARY
2. TURN ON CONTROL PANEL IN NEXT MONITOR
128

FIG. 12

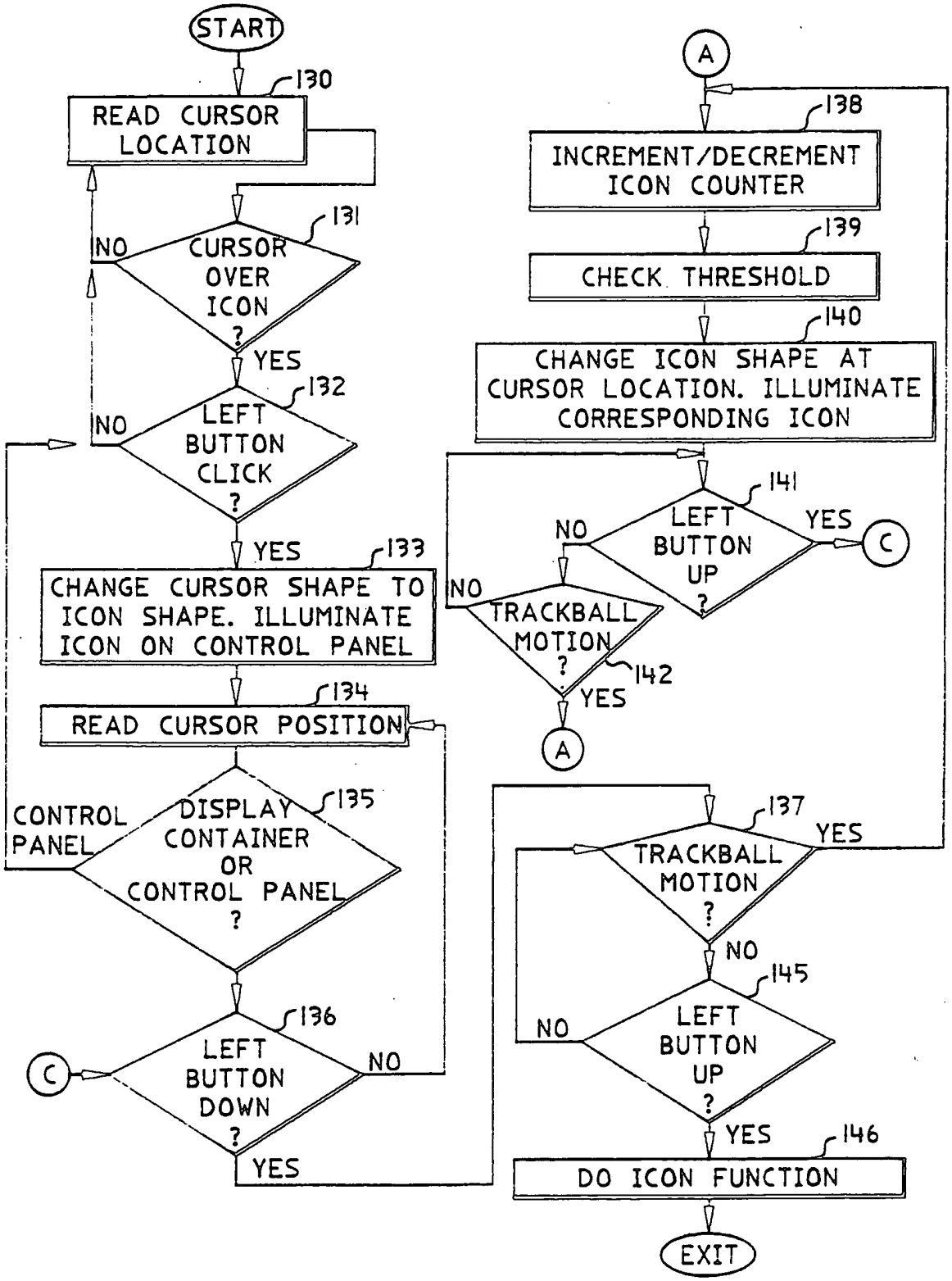

START
130
READ CURSOR LOCATION
131
NO
CURSOR OVER ICON ?
YES
132
NO
LEFT BUTTON CLICK ?
YES
133
CHANGE CURSOR SHAPE TO ICON SHAPE. ILLUMINATE ICON ON CONTROL PANEL
134
READ CURSOR POSITION
CONTROL PANEL
135
DISPLAY CONTAINER OR CONTROL PANEL ?
136
C
LEFT BUTTON DOWN ?
NO
YES
A
138
INCREMENT/DECREMENT ICON COUNTER
139
CHECK THRESHOLD
140
CHANGE ICON SHAPE AT CURSOR LOCATION. ILLUMINATE CORRESPONDING ICON
141
NO
LEFT BUTTON UP ?
YES
C
NO
TRACKBALL MOTION ?
142
YES
A
137
TRACKBALL MOTION ?
YES
NO
145
NO
LEFT BUTTON UP ?
YES
146
DO ICON FUNCTION
EXIT

FIG. 13

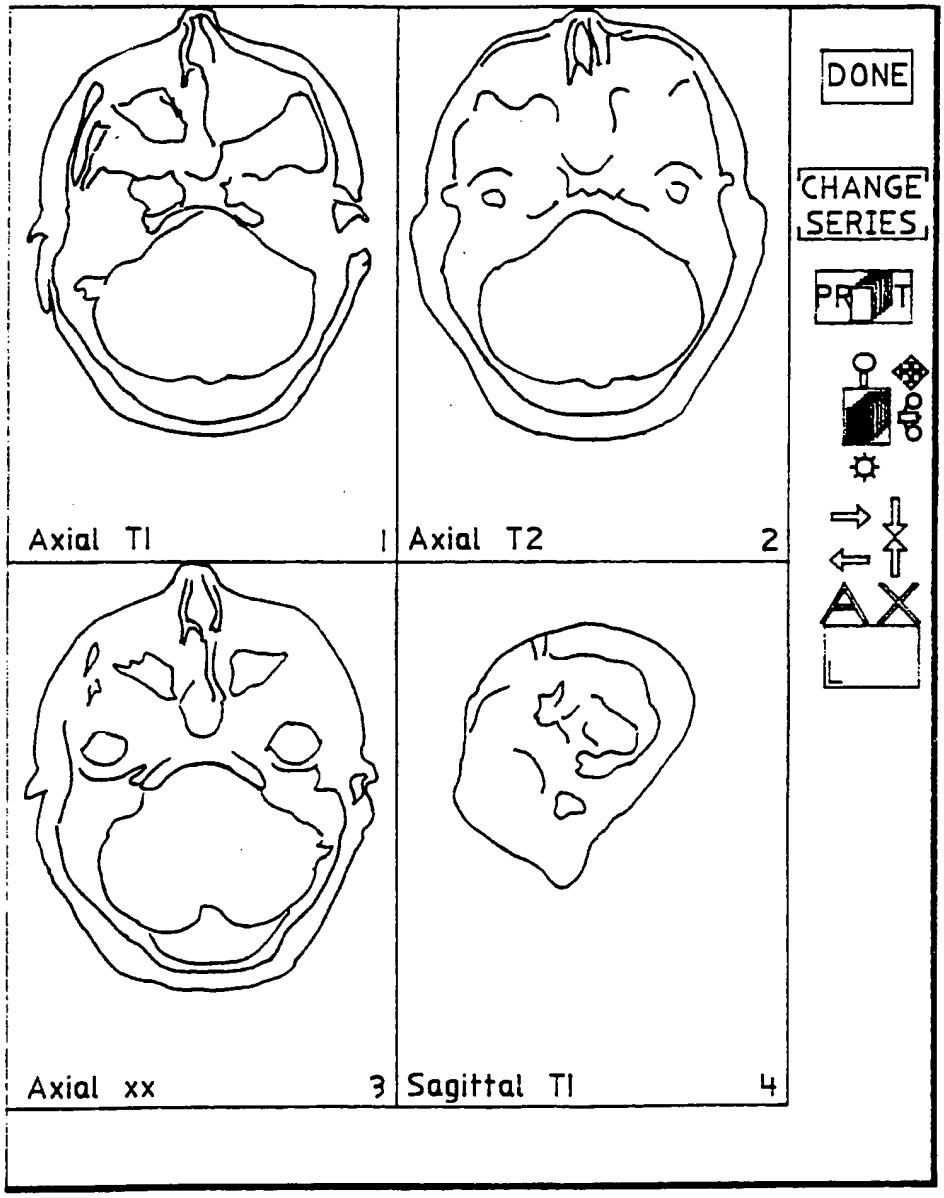


FIG. 14a

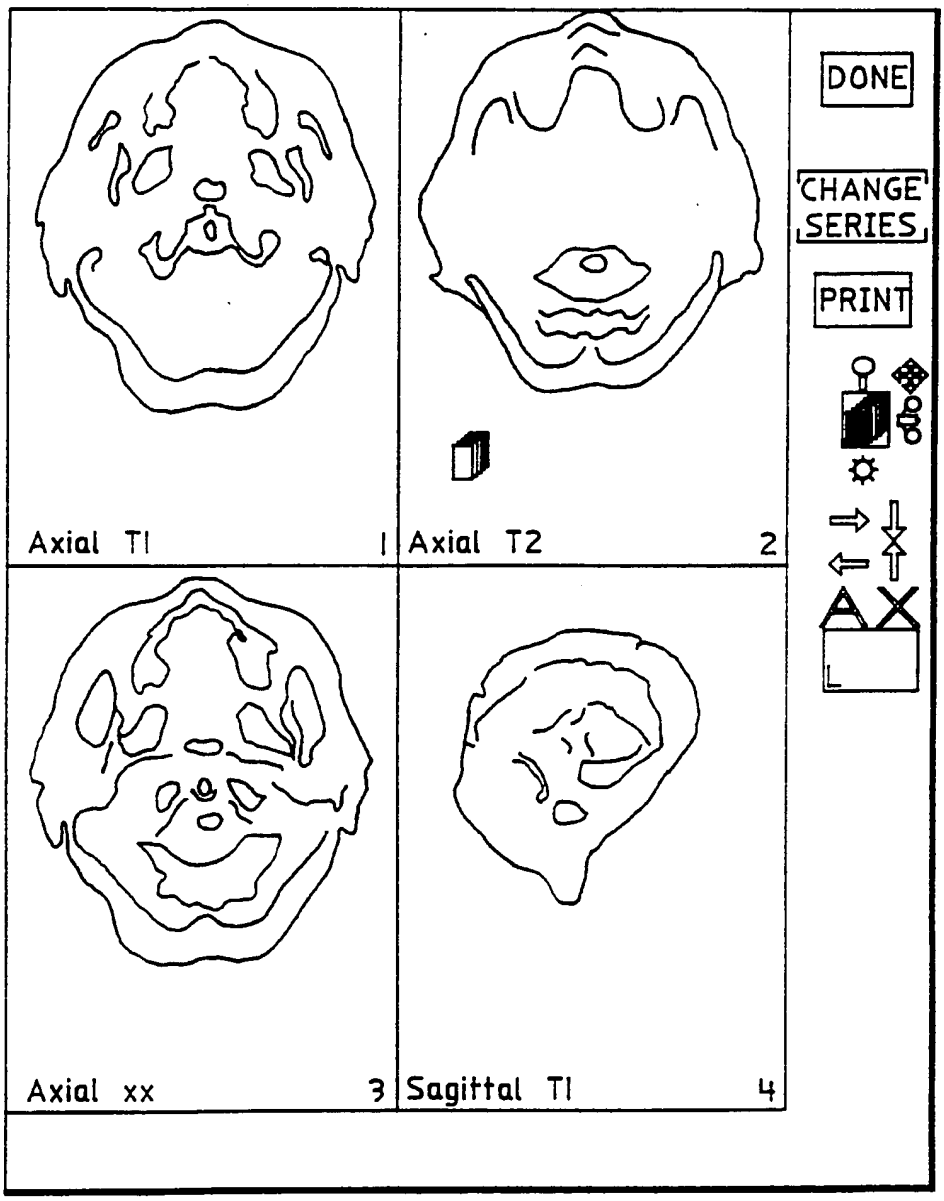

DONE
CHANGE SERIES
PRINT
Axial T1 1
Axial T2 2
Axial xx 3
Sagittal T1 4

FIG. 14b

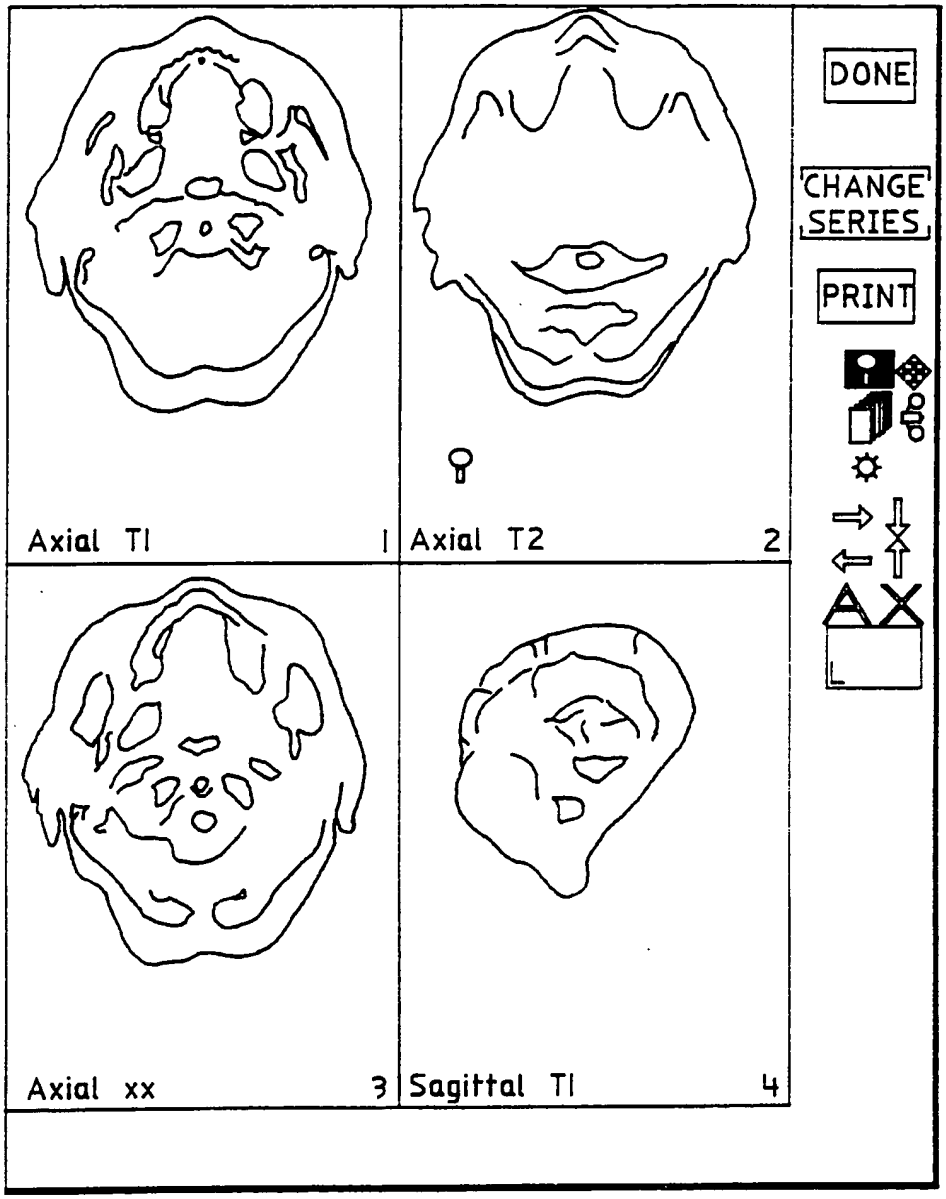

DONE
CHANGE SERIES
PRINT
Axial T1 1
Axial T2 2
Axial xx 3
Sagittal T1 4

FIG. 14c

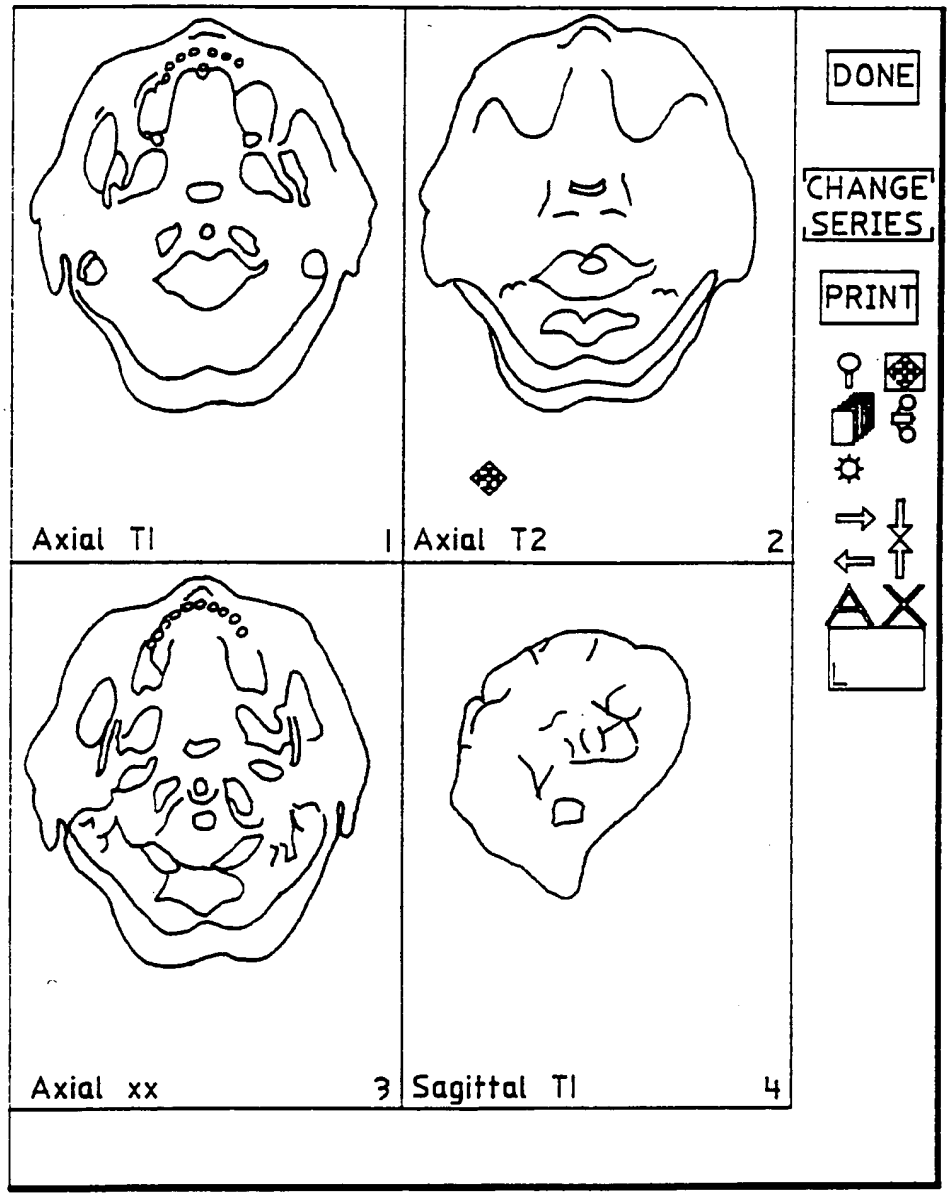

DONE
CHANGE SERIES
PRINT
Axial T1 1
Axial T2 2
Axial xx 3
Sagittal T1 4

FIG. 14d

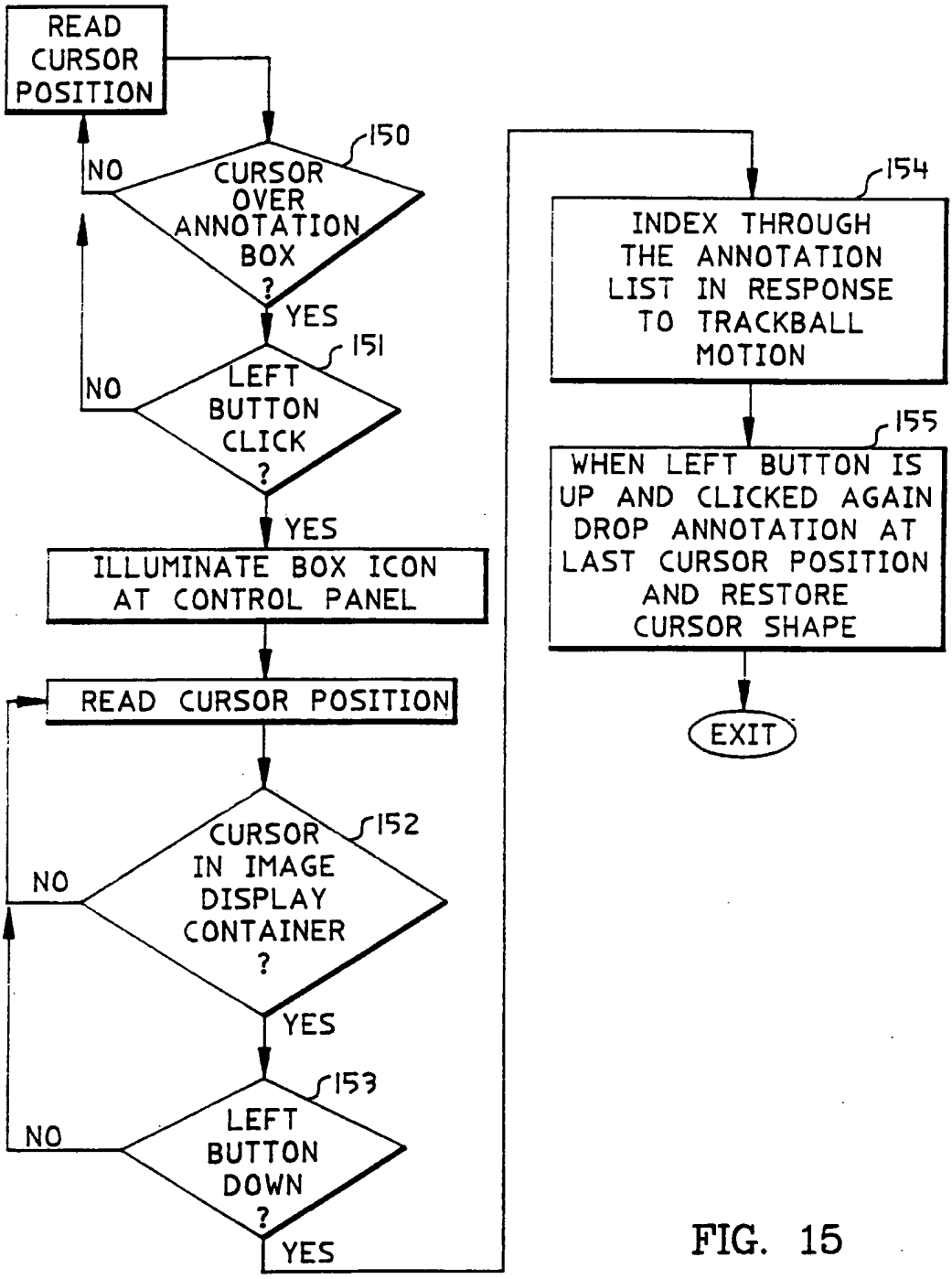

READ CURSOR POSITION
150
CURSOR OVER ANNOTATION BOX ?
NO
YES
151
LEFT BUTTON CLICK ?
NO
YES
ILLUMINATE BOX ICON AT CONTROL PANEL
READ CURSOR POSITION
152
CURSOR IN IMAGE DISPLAY CONTAINER ?
NO
YES
153
LEFT BUTTON DOWN ?
NO
YES
154
INDEX THROUGH THE ANNOTATION LIST IN RESPONSE TO TRACKBALL MOTION
155
WHEN LEFT BUTTON IS UP AND CLICKED AGAIN DROP ANNOTATION AT LAST CURSOR POSITION AND RESTORE CURSOR SHAPE
EXIT

FIG. 15

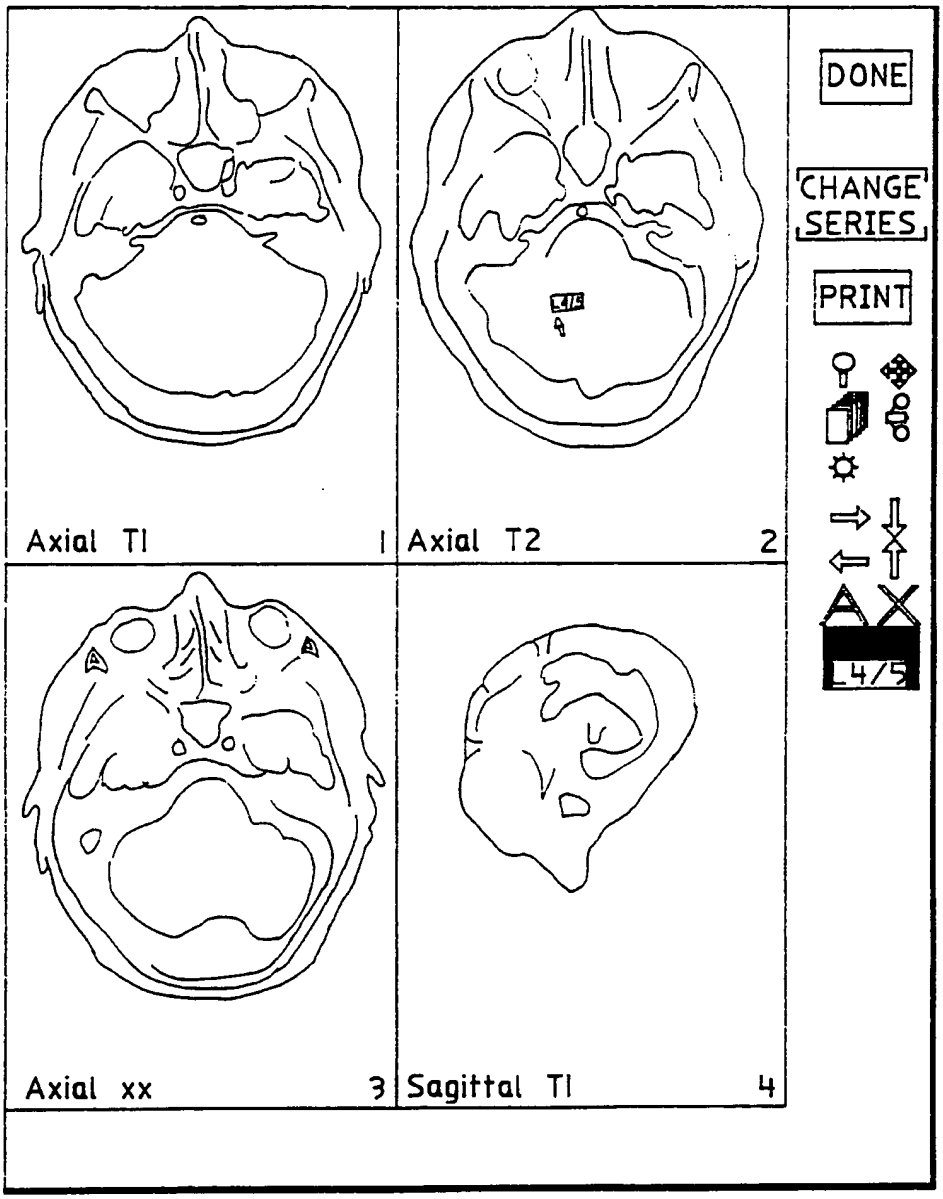


FIG. 16

INTERNATIONAL SEARCH REPORT

Interna .l Application No
PCT/US 93/12580

A. CLASSIFICATION OF SUBJECT MATTER
IPC 5 G06F15/42

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 5 G06F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	PROCEEDINGS OF COMPUTER-BASED MEDICAL SYSTEMS, IEEE COMPUTER SOCIETY PRESS NEW YORK US 14 June 1992 , DURHAM NORTH CAROLINA US pages 138 - 146 XP000308270 J.A.SANDERS ET AL 'DESIGN AND IMPLEMENTATION OF A CLINICAL MSI WORKSTATION' see page 140, line 10 - page 141, line 5	1-5,8,9
Y	see page 142, line 36 - page 144, line 8	6,7

-/--

[X] Further documents are listed in the continuation of box C.

[ ] Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
6 June 1994	17. 06. 94

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+ 31-70) 340-2040, Tx. 31 651 epo nl, Fax (+ 31-70) 340-3016	Barba, M

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INTERNATIONAL SEARCH REPORT

Interna tl Application No
PCT/US 93/12580

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	PROCEEDINGS OF THE 12TH ANNUAL INTERNATIONAL CONFERENCE OF THE IEEE ENGINEERING IN MEDICINE AND BIOLOGY SOCIETY, IEEE PRESS NEW YORK US vol. 1/5 , 1 November 1990 , PHILADELPHIA PENNSYLVANIA US pages 219 - 220 XP000239502 YONGMIN KIM ET AL 'A NEXT-BASED HIGH PERFORMANCE IMAGE COMPUTING WORKSTATION FOR BIOMEDICAL APPLICATIONS' see page 219, right column, line 37 - page 220, left column, line 29	6,7
A	see page 220, left column, line 34 - line 47	1-5,8,9

A	VISUAL COMPUTER, SPRINGER VERLAG vol. 4, no. 2 , 1988 , GERMANY pages 98 - 108 MOHAMMED ERRADI ET AL 'VISUAL INTERACTION USING AN ICONIC SYSTEM' see page 99, left column, line 42 - page 101, left column, line 18	1-9

A	SIGBIO NEWSLETTER vol. 12, no. 1 , February 1992 , NEW YORK US pages 10 - 22 XP000355128 M.D.DOYLE 'PALETTE SEGMENTATION INDEXING: ZHE METAMAP PROCESS' see page 20, right column, line 35 - page 21, left column, line 27	1-9

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